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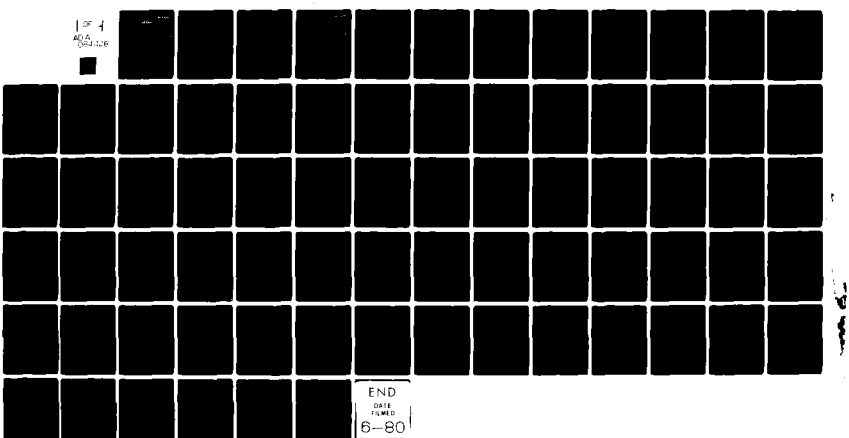

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LEVEL II

Development of Simulator Instructional Feature Design Guides

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October 1979

Prepared for:

Air Force Office of Scientific Research
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Bolling Air Force Base, DC 20332

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A project to develop guides for the design of simulator instructional features is described. Twelve instructional features, e.g., record/playback, automatic demonstration, and freeze, appropriate to a fighter/attack type aircraft simulator were identified. Information concerning each feature was obtained through observation of simulator instructional activities and review of training requirements and practices. The types of pilots likely to undergo training in a fighter/attack aircraft were examined to identify learner-

(continued)

related simulator design requirements. A guide format was developed that would permit organization of pertinent information in a manner useful to simulator design personnel. The guides were reviewed by personnel involved in the development of both aircraft and non-aircraft simulators and were judged useful as a mechanism for clarifying design requirements, communicating between training and simulator design personnel, highlighting design shortfalls, and clarifying simulator testing requirements.

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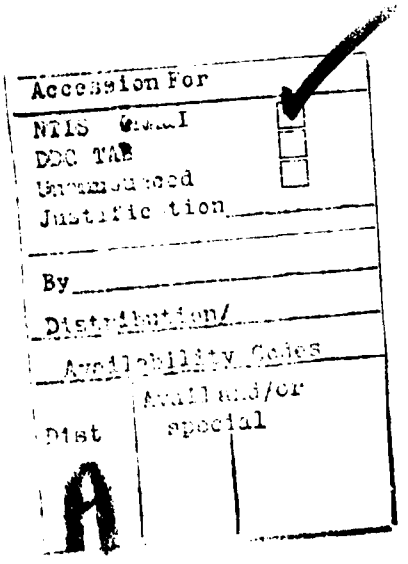
FOREWORD

This report describes a research project that was undertaken to develop a mechanism for communicating to simulator design personnel information about the intended use of the simulator they are to design. The research was sponsored by the Life Sciences Directorate, Air Force Office of Scientific Research, Air Force Systems Command, under Contract No. [redacted]. Major Jack Thorpe was the Program Manager for AFOSR. Dr. Paul W. Caro was the Principal Investigator for Seville.

Dr. Joseph H. Grosslight, Department of Psychology, Florida State University, served as a consultant to the project reported here. Dr. Grosslight's assistance in assessing the significance of learner characteristics for simulator design is appreciated.

A paper summarizing this report, titled "Development of Simulator Instructional Feature Design Guides," was presented at a symposium titled "50 Years of Flight Simulation," London, 24 April 1979. The symposium was sponsored by the Royal Aeronautical Society and the American Institute of Aeronautics and Astronautics. A paper based upon this project, titled "A Mechanism for Communicating Simulator Instructional Feature Requirements," was presented at the 1st Interservice/Industry Training Equipment Conference, Orlando, Florida, 28 November 1979. These papers appear in the published proceedings of the respective conferences.



SUMMARY

BACKGROUND AND PURPOSE

Several researchers have noted that instructional features of flight simulators are often inefficiently designed. Although various features may be included, their capabilities may not correspond to specific training needs, and in many instances the features have been awkward to use. The principal difficulty appears to be the lack of knowledge of intended uses of the features while they are being designed. Often, there is no clear conception of the training to be provided nor of how, and for what reasons, an instructor will use a feature. This lack of information is probably due in part to the absence of a convenient mechanism to acquaint simulator designers with training requirements that pertain specifically to instructional features.

The project described here developed guides for designing instructional features. The format for the guides and the nature of their content permit communication of required feature characteristics from an intended user to the designer. Because of the clarity of communication that can be possible with the guides, decisions regarding cost/technology trade-offs can be made with greater awareness of the consequences for training. The availability of this guidance should lead to the development of more usable training features, and hence to more effective and efficient instruction.

APPROACH AND RESULTS

A fighter/attack type aircraft simulator was the basis for developing an exemplar set of guides. Twelve instructional features appropriate to that type simulator were identified. Information concerning each feature was obtained through observation and review of simulator instructional activities, training requirements, and training practices associated with the type aircraft under consideration. A format, applicable to all 12 features, was developed that would permit organization of pertinent information in a manner that could be readily understood by simulator design personnel.

Types of pilots likely to undergo training in a fighter/attack aircraft simulator were also examined to determine whether individual pilot characteristics might have implications for simulator design. It was found that a wide range of experience levels would have to be accommodated, and that a degree of self-control over the instructional process would be beneficial to learning for some pilots. These factors were taken into account in guide development.

INITIAL VALIDATION EFFORTS

The 12 design guides developed during the project were reviewed by

personnel involved in all phases of the design, development, and training uses of flight simulators. It was their consensus that the guides would be useful in future simulator projects as a mechanism for clarifying simulator design requirements, communicating between training and design personnel, highlighting design shortfalls, and clarifying simulator testing requirements. The guides are currently being used in conjunction with the development of simulators for a utility-type jet airplane and a helicopter. In addition, the guides have been used, in modified form, to clarify requirements for the design of a simulator for a tank and to facilitate communication of design information between that device's eventual user and the developer. Experiences gained with the guides on these projects will provide further information concerning their utility during the simulator design process.

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I. INTRODUCTION

BACKGROUND

The history of flight simulation has been characterized by almost constant advances in the capabilities and complexity of flight training devices. Most of these advances have involved increased fidelity of simulation. That is, simulator design has emphasized physical correspondence between the device and the aircraft simulated. As a result, flight simulators increasingly look, feel, sound, and perform like aircraft.

The emphasis upon fidelity in simulator design has resulted in devices that are costly to procure and operate. In spite of such costs, however, fidelity in flight simulators is widely acclaimed as useful and, in many cases, even essential to effective training. Because of the cost of high-fidelity devices, the development of simulator designs that permit more efficient training is a necessary goal.

An efficiently designed simulator is a device whose instructional features permit instructional activities to be conducted with a relative minimum of time and effort. Most recent efforts to develop more efficient simulators have sought to achieve greater efficiency by eliminating the instructor from portions of the instructional process through development of instructional features that permit automatic training and performance measurement.[1] A few studies have examined the role of the instructor in nonautomatic simulator training and the manner in which the simulator's instructional features facilitate or hinder that role. These latter studies have concentrated upon the simulator instructor/operator station (IOS)--the locus of control of most instructional features--and the extent to which IOS design impacts instructional efficiency.

In one study of IOS designs, Charles, Willard, and Healy[2] observed that some of the newer flight simulators are less efficiently designed than older ones. They noted that earlier designs, while not based on systematically derived training requirements, were sufficiently constrained by display and control technology to result in a meaningful and relatively efficient IOS arrangement for the instructor. Today, by contrast, advanced control and display technology has been exploited seemingly to cover all possible contingencies rather than to permit conduct of necessary instructional activities in an efficient manner.

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[1] Brown, J. E., Waag, W. L., & Eddowes, E. E. USAF evaluation of an automated adaptive flight training system (AFHRL-TR-75-55). Williams Air Force Base, AZ: Air Force Human Resources Laboratory, October 1975.

[2] Charles, J. P., Willard, G., & Healy, G. Instructor pilot's role in simulator training (NAVTRAEQUIPCEN 75-C-0093-1). Orlando, FL: Naval Training Equipment Center, March 1976.

Charles, et al., concluded that "Efficient training console design can be accomplished, but only if display and control designs are based on information and action requirements . . . . Thus, the role of the [simulator instructor/operator] must be defined in detail and the operational concept developed" (page 76).

Inefficiencies in IOS design were also noted by Isley and Miller[1] during an examination of both military and commercial flight simulators. They reported that modern simulators incorporate a large number of presumably useful instructional features, but that many of these features are not being used in the conduct of simulator training. Two reasons were given to account for this situation: (1) the designs of simulator instructional features were inefficient, and use of the features often proved time consuming and awkward; and (2) the features themselves were in some cases inappropriate to the training being conducted in the devices. Isley and Miller noted that the designs of the simulators they examined appeared to have been developed in the absence of information concerning the operational concept of the training to be provided or about the intended role of the instructor. That is, the kind of information needed for design of an efficient IOS (as identified by Charles, et al.) probably was not available to the designers of the simulators Isley and Miller examined.

Review of the process in which simulators are designed, especially U.S. military flight simulators, confirms the general absence of such information. Simulator specifications and other design and procurement documents seldom address operational training concepts or instructor roles. These documents present design guidance primarily in terms of information about the aircraft to be simulated and its operational environment. Even statements of training objectives and course syllabi, when available, typically describe only the skills and knowledges a pilot needs to acquire and the sequence of training tasks to be performed in the planned simulator. This additional guidance, though helpful concerning the needs for simulation, is vague at best for the design of instructional features. While instructional features may be specified, the manner in which they are expected to be employed by the users of the simulator simply is not made known to the device designer. Therefore, he has insufficient basis for assessing the relative efficiency of instructional feature design alternatives.

Isley and Miller did note that there are simulators in which some instructional feature designs permit efficient training in spite of the absence of information about the manner of their intended use. Such features were used during training with these simulators and were judged to increase the efficiency of training in the devices. After further study by the present authors of several of the simulators examined by Isley and Miller, it was concluded that the relatively efficient design of some of their instructional features probably was achieved in part by "simulating" representative training activities, using a mock-up of the

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[1]Isley, R. N., & Miller, E. J. The role of automated training in future Army flight simulators (Final Report, Contract N61339-76-C-0050). Orlando, FL: Project Manager for Training Devices, October 1976.

simulator's IOS and trainee station and modifying the mock-up as required to permit training activities to be conducted efficiently. Unfortunately, those efforts tended to be unsystematic and incomplete because of the limited time during which the mock-up was available to personnel familiar with simulator usage. Further, these efforts usually occurred after most of the design decisions had been made, and only questions related to control-display arrangements remained to be answered.

Properly used, instructional features can impact both the efficiency and effectiveness of training. Thus, information about their intended use should be available during the design process. Specifically, the designer needs to know how, and in what types of circumstances, the instructional features are to be employed during simulator instruction. The problem, then, is to assemble the needed information and to make it available to the designer early in the simulator design process. A convenient mechanism for resolving this problem does not appear to be available at the present time.

PURPOSE

The present paper describes a project in which a solution to the problem identified above was sought. In the project, descriptions were developed of simulator instructional activities associated with a number of instructional features found on current generation flight simulators. These descriptions provided information about the use of simulator instructional features. It was intended that these descriptions, appropriately formatted, become design guides and provide the mechanism needed to facilitate communication between simulator users and designers.

APPROACH

A number of factors should be considered in the design of instructional features for flight simulators. The type of aircraft simulated, the nature of the training to be conducted, the characteristics of the pilots to be trained, and the roles and responsibilities of various personnel directly involved in simulator usage are all pertinent for specific capabilities of features. These factors vary with simulators and with individual training programs and practices. Yet, it was felt that with an adequate perspective concerning these factors, an exemplar set of guides could be developed which apply to a particular training context, but which also could be adapted to a variety of simulators and training missions.

One set of activities thus was directed at defining a context for exemplar guides, while simultaneously assuring their general applicability. These activities included (1) selecting a particular type of simulator for which design guides would be developed; (2) examining existing simulators and their use so that a variety of instructional activities could be observed; (3) ascertaining the roles and responsibilities of simulator training personnel; and (4)

identifying types of pilot characteristics that should be considered in instructional features designs.

A second set of activities concerned the development of the guides themselves. Based upon information obtained from the four activities above, a list of useful instructional features was drawn up, and capabilities needed for each feature were defined. A format was then developed for describing the requirements of each feature in a way that permitted precise communication between simulator users and designers.

Each type of activity is described below, along with the outcome of that activity and its relevance to the development of the design guides.

REPORT ORGANIZATION

This Technical Report is divided into four major sections and an appendix. The present section is an introduction to the project. Section II identifies factors to be considered in developing guides for designing instructional features. Section III describes the features selected for development and the format for the guides. Section IV summarizes the initial efforts toward determining the utility of the guides. The Appendix contains the simulator instructional feature design guides developed during the project.

II. FACTORS TO BE CONSIDERED IN INSTRUCTIONAL FEATURE DESIGN

SELECTION OF A SIMULATOR TYPE

It might seem desirable to develop a single, generalizable design guide for each instructional feature. Such guides then could be used in the design of all future simulators. However, such an effort would be comparable to that of seeking a single aircraft, environment, or training objectives model that could be employed in the design of all future simulators. Instead, it was assumed that, while some of the guides would be suitable for a wide range of simulators, others would have to address instructional features and activities that might be specific to certain types of simulators. The principal factors of concern that distinguish types of simulators and that could influence instructional feature design are the crew configuration of the aircraft simulated (i.e., single-crewman vs multi-crew), the aircraft mission (e.g., transport or attack), the kinds of training intended (e.g., instrument flight, full mission, or procedures), and simulator configuration (e.g., whether the IOS is located adjacent to or remote from the cockpit, and whether the simulator has or does not have an extra-cockpit visual display).

It was decided to develop the guides for the instructional features of a specific simulator currently under development. This approach provided a context within which to consider instructional activity alternatives. It also afforded access to simulator design personnel. At the time the project was initiated, the development of a simulator for the F-16 aircraft was underway. The F-16 is a single-crewman, fighter/attack aircraft. The F-16 simulator has a one-window visual display and a remote IOS; it was designed for instrument, intercept, weapons, and limited transition training. Similar simulators will be required for other fighter/attack type aircraft in the future, thus offering the possibility of using and evaluating the instructional feature design guides during the subsequent development of such devices. Therefore, it was decided that the guides would be oriented toward instructional features suitable for a device such as the F-16 simulator then under development.

It was also decided, however, that the guides would not be limited to the proposed design features of the F-16 simulator or of any other existing or planned device. Further, to avoid interference with the F-16 simulator project, there was no attempt to employ the guides being developed to influence the design of the F-16 device. Thus, except for observation of selected F-16 simulator project activities and discussion of those activities with project personnel, the present effort proceeded independently of the project in which the F-16 device was being developed.

The study of the F-16 simulator identified two factors that were judged to be particularly important with respect to the instructional feature design guides to be developed in this project. These factors are described below.

- Single-crewman aircraft. The fact that the aircraft has a single crew position makes it impossible for the instructor to perform many of the functions often performed in simulators (and aircraft) having a position for a second flight crewman. These instructor functions include assisting the pilot in the performance of difficult tasks early in training and demonstrating desired maneuver performance.

- Remote IOS. Many fighter/attack aircraft simulators locate the IOS remote from the cockpit rather than adjacent to it. From an IOS located adjacent to the cockpit, the instructor can observe the pilot during training, and the pilot can see IOS displays when the instructor wishes him to do so. The F-16 simulator of interest in the present project has the remote IOS configuration. The direct pilot-instructor visual contact permitted by this configuration is limited. Therefore, the selection and design of instructional features for this simulator must compensate for this limitation.

EXAMINATION OF EXISTING SIMULATORS

In examinations of existing simulators, particular attention was paid to the instructional features included in those devices and the manner in which they were used, if at all, during training. The simulator instructors were asked for comments about the frequency and circumstances of their use of the principal features of each device and their suggestions for possible changes in the features that might increase their usefulness. The simulators examined included devices for the F-4 and F-15 fighter aircraft as well as several of the simulators included in the previously described study conducted by Isley and Miller.[1]

In addition to examining existing simulators, the performance specifications for two simulators currently under development were reviewed. These specifications were for the previously mentioned F-16 simulator and a simulator for the A-10 aircraft. Particular attention was directed to the requirements in the specifications for the inclusion of simulator instructional features and to the descriptions of performance requirements for these features.

Further information about instructional activities appropriate for simulator training, particularly for fighter/attack type aircraft simulators, was obtained through discussions with operational and instructor pilots. These discussions concentrated upon identification of training practices in the aircraft as well as in simulators. Of particular concern were the variety of instructional features, the innovative uses of these features, and any recognized shortcomings that would reveal desirable characteristics to be included in future designs.

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[1] Isley, R. N., & Miller, E. J. The role of automated training in future Army flight simulators (Final Report, Contract N61339-76-C-0050). Orlando, FL: Project Manager for Training Devices, October 1976.

SIMULATOR TRAINING PERSONNEL

Before the simulator instructional feature design guides could be developed, it was necessary to formulate concepts of the roles of the personnel in the simulator instructional process. Therefore, a description of these roles was prepared. The description was generally modeled after, but was not limited to, the observed roles of personnel in comparable Air Force simulator training activities, e.g., F-15 simulator training. Specific deviation from such roles was made where, in the judgment of the project staff, other practices would be preferable in terms of training efficiency, and where the characteristics of the learner suggested that provisions should be made for activities not currently included in such training, e.g., provision for a greater degree of self-controlled instruction than is currently being employed.

There are three principal personnel involved in the instructional process for the type of simulator under consideration: the instructor, the pilot, and the device technician or operator. The roles of these personnel are dependent upon the instructional activities in progress and the relative skills of the pilot receiving instruction. These roles are described below.

The Simulator Instructor

The simulator instructor will be a pilot on flying status who meets the proficiency and experience standards required of a flight instructor in the aircraft simulated. He normally will occupy a position at the IOS, although he may on occasion instruct from a position beside the pilot (e.g., when introducing a newly assigned pilot to the cockpit and conducting training related to procedural tasks if a procedural trainer is not used). On these latter occasions, his direct control of simulator instructional features will be limited to freeze, reset, and communications functions, and he will interact visually and orally with the pilot during such instruction.

All instructional features of the simulator will be under the simulator instructor's direct and immediate control from the IOS. The IOS will normally be occupied by a single simulator instructor, although its physical arrangement will permit a second individual (a simulator instructor "trainee" or a device technician) to participate in the instructional process. The efficient conduct of instruction from the IOS will not be dependent upon or encumbered by the presence of a second instructor or a device operator, however.

From the IOS, the simulator instructor will obtain all the information needed to determine which instructional activities are required, and, using the controls and communication linkages available there, he will conduct those activities. The instructor will base his instruction upon syllabus requirements and upon observation of the performance of the pilot undergoing instruction. Such observation will be via CRT displays, repeater instruments, and audio channels. Displays at the IOS will enable the simulator instructor to observe the information presented to the pilot in the cockpit, to assess the relevance and correctness of ongoing pilot performance, to review

pertinent performance parameters over a recent time period, and to identify errors or deficiencies in that performance and the circumstances surrounding their occurrence.

The extent of control of the instructional process by the simulator instructor will be greatest when the pilot undergoing instruction is inexperienced in the aircraft simulated or is unfamiliar with particular operational performance requirements. When instructing relatively experienced pilots, the need for the instructor may diminish, although he will continue to exercise control over the displays and controls at the IOS in order to present the training situation required, to assess the adequacy of pilot performance, and to assist the pilot in the development of higher order operational skills not addressable directly through the simulator's instructional features. In those instances in which a skilled pilot is practicing previously acquired skills and/or is engaged in the performance of "canned" or automatically administered mission activities, a simulator instructor may not be required at all, and his position at the IOS could be occupied by another pilot or a simulator technician.

The Simulator Pilot

The role of the pilot during simulator training varies from that of a recipient of instruction to a self-instructor, dependent upon syllabus requirements, the availability of preprogrammed missions, his relative skill level, and his preference for self-instruction. When transitioning to the aircraft simulated or when being introduced to a new task or tactic, the pilot will be primarily a recipient of instruction administered by the simulator instructor. As he acquires greater skill, the pilot will become more active in the diagnosis of his own performance deficiencies and in the selection of instructional events and simulated situations for further skill development. Finally, when he attains a relatively high skill level and instructional or performance evaluation activities are not prescribed by syllabus or regulatory requirements, he will assume responsibility for and control of his own instructional activities, and the need for a simulator instructor will be greatly reduced or eliminated.

The proficient pilot exercising control over his own simulator instruction will employ a combination of controls located inside the cockpit and at the IOS. The cockpit controls, which will be limited to those needed to perform basic simulator functions such as freeze, storing initialization conditions, and resetting to such conditions, will be operated directly by the pilot. The controls located at the IOS will be operated by personnel at the IOS in response to pilot requests for information and/or modification to the simulation or in accordance with syllabus or scenario requirements.

When a pilot is flying the simulated aircraft, the IOS will always be occupied for safety and security reasons. The occupant will normally be another pilot--either a simulator instructor or a peer of the pilot in the cockpit--although on occasion the sole occupant of the IOS may be a nonpilot simulator technician. A simulator instructor will be present when his instructional skills might be required and/or when formal pilot performance evaluation activities are prescribed. When the pilot in the

cockpit is responsible for the conduct of his own training, that is, when he is practicing previously acquired skills or is performing an automatically administered training mission, the occupant of the IOS need not be trained as a simulator instructor. Any other pilot who is qualified in the aircraft simulated and is familiar with the principal features of the simulator may, from the IOS, manage the training scenario, simulate radio communications, and communicate displayed status and performance information to the pilot in the cockpit so that he may conduct his own training more effectively. When the pilot peer at the IOS has only limited familiarity with the IOS controls, he will normally be assisted in the operation of those controls by a simulator technician.

The Simulator Technician

The simulator technician is skilled in the operation of the simulator, but he has limited knowledge of the operation of the simulated aircraft or the missions in which it is likely to be employed. Consequently, he does not normally interact with the pilot in the cockpit for the purpose of instructing him, providing interpretation of displayed information, or assessing his performance. The role of simulator technician in the instructional process is a supporting role and is limited to setting up scenarios and simulated mission situations selected by the instructor or the pilot and performing other instructional support and communication tasks when requested to do so by the simulator instructor or pilot peer occupying the IOS. A simulator technician will always be present when the IOS is occupied by a pilot who is not specifically trained as a simulator instructor. When a simulator instructor occupies the IOS, the technician's presence will be at the option of the instructor.

Since his role in the instructional process is secondary to that of the simulator instructor or pilot peer, the technician will occupy a secondary position at the IOS. He will have convenient access to controls and displays necessary to the performance of likely instructional support functions, some of which may be time-shared with the instructor.

CHARACTERISTICS OF THE LEARNER

A factor considered in the development of the simulator instructional feature design guides was the learner himself, i.e., the pilot undergoing instruction. The issue was whether there were characteristics of pilots, in this case, candidate F-16 pilots, that might require special consideration in instructional feature design. Characteristics of the F-16 pilot candidate population have been investigated by Gibbons, Thompson, Schmid, and Rolnick.[1] These investigators concentrated largely upon demographic data and identified

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[1]Gibbons, A. S., Thompson, E. A., Schmid, R. F., & Rolnick, S. J. F-16 pilot and instructor pilot target population study (F-16 Aircrew Training Development Project Report #13, Contract No. F-77-C-0075). San Diego, CA: Courseware, Inc., September 1977.

no unique characteristics of that population that were judged to require special consideration in the design or use of simulator instructional features. However, they did note that a wide range of skills will be represented. The population of F-16 pilots will include newly rated pilots as well as highly experienced combat veterans. Such a range suggests that the training to be conducted in simulators such as the F-16 device currently under development will include the acquisition of new skills as well as the refinement of already highly developed ones.

A recent survey of the psychological literature dealing with learner characteristics examined cognitive (learning) styles and identified ten style variables that were judged as most relevant to technical kinds of training.[1,2] Several of these variables would appear to have implications for pilot training. One variable, field independence-dependence, appeared to the present authors to be relevant to instructional activities in a simulator.

The literature suggests that the field-independent individual would likely benefit more than the field-dependent individual from simulator training which he was largely able to control himself. His success as a learner in a flight simulator would not depend upon an instructor for performance feedback, reinforcement, or direction. Field-dependent individuals, on the other hand, would likely be more dependent upon instructor-mediated feedback, reinforcement, and direction during training.

The investigation of the F-16 pilot candidate population conducted by Gibbons, et al., did not consider cognitive style variables, and the distribution of such variables within any pilot population is not known. It may be assumed, however, that both field-independent and field-dependent individuals will be found in most pilot groups, including fighter/attack aircraft pilot populations. Therefore, the design of simulator instructional features should accommodate both field-independent and field-dependent pilots.

From the report of F-16 pilot population characteristics and the recent survey of the cognitive style literature, several requirements were derived for the planned descriptions of instructional features. First, the instructional feature must accommodate relatively unskilled pilots who are unfamiliar with the tasks to be trained and may need extensive coaching, demonstration, and criterion-referenced feedback concerning their performance. However, these features must also accommodate the relatively skilled pilots who will require little

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[1]Ragan, T. J., Back, K. T., Stansell, V., Ausburn, L. J., Ausburn, F. B., Butler, P. A., Huckabay, K., & Burkett, J. R. Cognitive styles: A review of the literature (AFHRL-TR-78-90[I]). Brooks Air Force Base, TX: Air Force Human Resources Laboratory, May 1979.

[2]Back, K. T., Stansell, V., Ragan, T. J., Ausburn, L. J, Ausburn, F. B., Huckabay, K. Cognitive styles: A bibliography and selected annotations (AFHRL-TR-78-90[II]). Brooks Air Force Base, TX: Air Force Human Resources Laboratory, May 1979.

coaching and no demonstration, but much more detailed feedback so that they can hone skills that are already highly developed. These features should permit an instructor to be able to direct and structure training for the field-dependent pilots as needed. Additionally, the instructional features should permit field-independent pilots a degree of self-instruction and freedom to evaluate their own performance and to pursue their own perceived needs for further skill development.

III. DEVELOPMENT OF GUIDES FOR INSTRUCTIONAL FEATURES

Based on the information identified in the preceding section, 12 instructional features were selected for design guide development. This section explains the nature of the features and describes the format for the guides. The guides themselves appear as an appendix (in the format described below).

THE INSTRUCTIONAL FEATURES

The simulator instructional features for which design guides would be developed were those judged to have maximum potential application to the F-16 simulator as well as to other types of simulators. In addition, instructional features were selected for design guide development that were representative, with respect to function, of other instructional features, and thus could serve as examples for the development of guides for similar features. For example, the selected feature involving the automatic insertion of malfunctions can serve as an example for a feature involving the automatic insertion of other kinds of events. Several instructional features that are sometimes considered independent of each other were combined and treated as a single instructional feature, because it was judged that they were not likely to be employed independently during the process of simulator instruction. For example, instructional features involving the recording and on-line playback of both simulator performance and audio were treated as a single instructional feature for the purpose of the present project.

The 12 instructional features are described briefly below.

- Record/Playback. Permits the replay of a recent or immediately preceding segment of recorded flight.

- Store/Reset Current Conditions. Permits the simulator to be reset by the pilot or the instructor to a situation or set of simulated conditions that existed at an earlier time.

- Remote Display. Permits alphanumeric and graphic data displayed at the IOS to be displayed simultaneously to the pilot in the cockpit.

- Hardcopy. Enables the instructor to reproduce on paper perishable information displayed on a CRT at the IOS.

- Manual Freeze. Enables the instructor or the pilot to freeze or suspend ongoing simulated activity resulting from actual or recorded input to the aircraft's controls or from the simulator programs.

- Automatic Freeze. Similar to Manual Freeze except that it is initiated automatically, contingent upon specified events such as crashing the simulated aircraft into the ground.

- Parameter Freeze. Enables the instructor to freeze one or more of the parameters of simulated flight.

- Demonstration. Consists of prerecorded aircraft maneuvers or series of contiguous maneuvers to be used as models of the desired performance for the maneuvers demonstrated.

- Demonstration Preparation. Enables a simulator instructor to prepare a Demonstration for repeated use during subsequent periods of pilot training. This feature is necessary if Demonstration is to be incorporated into simulator design.

- Malfunction Simulation. Enables an instructor to fail, partially or totally, a simulated aircraft component.

- Automatic Malfunction Insertion. Consists of a training exercise in which simulated aircraft malfunctions are inserted automatically when previously specified conditions have been met. (This feature is representative of a class of automatic training exercises in which a training situation is programmed to occur or is modified contingent upon the occurrence of one or more prior events. The feature design guide itself may serve as a model for the description of other features in which contingent relationships may be established, e.g., target insertion, hostile weapons release, weather modifications, and/or communications/navigation station failures.)

- Automatic Malfunction Insertion Exercise Preparation. Enables a simulator instructor to prepare an Automatic Malfunction Insertion exercise for repeated use during subsequent periods of instruction. (As with the Automatic Malfunction Insertion feature, this feature design guide also can serve as a model for other features having similar functional requirements.)

DEVELOPMENT OF A DESIGN GUIDE FORMAT

The format for the guides must permit communication of process-of-use information to engineering and other simulator design personnel who have limited knowledge of how training in a simulator is conducted or how instructional features might be employed during training. Accordingly, a guide format was developed that permitted presentation, both verbally and diagrammatically, of information judged to be needed in order to design an instructional feature with which efficient training could be conducted.

The final format consisted of the six elements identified below.

- Feature. Identifies the simulator instructional feature for which the guide was prepared.

- Definition. Defines the instructional feature. The intent of the definition is to assure a common understanding of what is meant when a particular feature name is used.

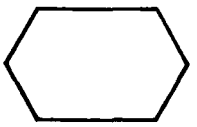
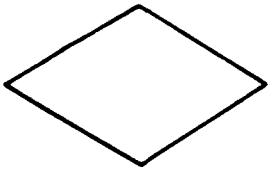
• Purpose and Intended Use. Describes the purpose served by the feature in a simulator and the manner in which it is intended to be used by the instructor and/or the pilot during the conduct of simulator training.

• Function Description. Describes each function involved in the employment of the instructional feature from its initial accession to completion of its use. The Function Description overlaps somewhat with Purpose and Intended Use. However, the purpose of this element is to isolate each function associated with use of the feature so that it may be defined more precisely and its relationship to other functions may be specified.

• Concurrent Events. Specifies intended restrictions on feature use, if any, and identifies other simulator instructional features that may be employed concurrently.

• Feature Diagram. Diagrams the functions involved in the use of the feature. Each item on the diagram corresponds to a function identified under the Function Description element. The format for the diagram is a flow chart in which each function is presented in the sequence in which it might be performed, and in which each decision required in the use of the feature is represented. Table 1 identifies the symbols used in the Feature Diagram element.

Table 1. Feature Diagram Symbols and Meanings

	Indicates the initiation or termination of use of a feature
	Indicates that a selection must be made among alternatives available in the simulation, e.g., selection of a malfunction to be inserted or removed.
	Indicates that an activity must be performed.
	Indicates that a yes-no choice must be made, e.g., whether or not to present a demonstration in slow time.
	Indicates the storage of data developed during a training or program development effort for use during subsequent periods of simulator instruction.

IV. INITIAL DESIGN GUIDE VALIDATION EFFORTS

The purpose of the guides developed during this project is to provide information about how flight simulator instructional features are intended to be used so that such information can be employed during simulator design. Uses to be made of the guides in accomplishing this purpose will depend upon the requirements of those employing them. In most simulator development projects, these uses could include the following:

- Clarifying design requirements. The guides can be reviewed by training personnel for whom the simulator is to be developed to determine whether their desires and expectations regarding planned instructional activities and simulator usage are correctly stated. If not, the guides may be revised by these personnel to fit their unique training requirements. Such reviews and revisions should result in clarification of the expectations as well as the requirements of the eventual simulator users.

- Communicating between training and design personnel. The guides provide a convenient mechanism for communicating to the designer the simulator capabilities required by training personnel. The guides might best serve this purpose if they are referenced in simulator performance specifications as an amplification or clarification of requirements for particular instructional features.

- Highlighting simulator design shortfalls. In some instances, the design expectations of training personnel may not be attainable due to cost or technology limitations. In such instances, the simulator designer or developer would be able to identify instructional feature functions specified in the guides that cannot be provided. Training personnel could then assess the impact of such shortfalls and seek alternate instructional activities for use with the device.

- Clarifying simulator testing requirements. The guides can provide a basis for the design of simulator acceptance or operational tests to determine the adequacy of each instructional feature incorporated into the device. The tests could examine individually and in an applications context each function of each feature, and the extent to which use of each feature is compatible with other features that must be used concurrently.

Whether the guides result in the design of more efficient simulators can only be determined after the guides have been employed in the design of simulators, and the efficiency of those simulators has been determined during operational training. Such an effort will take several years to accomplish. In the meantime, tentative evaluations can be made. Those evaluations which have been completed or are underway are described in this section.

REVIEWS BY F-16 SIMULATOR PROJECT PERSONNEL

As an initial indication of whether the guides could be employed for any of the purposes indicated above, they were reviewed by personnel involved in the F-16 simulator development project. The reviewers included a former member of the F-16 Instructional System Development (ISD) team who participated in the specification of instructional feature requirements for the simulator and represented the interests of the ISD team in those activities; an F-16 Project Officer from the U.S. Air Force Tactical Air Warfare Center, who represented the interests of the training personnel that eventually will use the simulator; and personnel from the project engineering staff of the developer of the simulator. These reviews were constrained by the fact that the F-16 simulator was already in the manufacturing process and did not incorporate all of the functions described in the guides.

The reviewers were asked to judge whether the guides would have been useful had they been employed early in the F-16 simulator project to clarify the requirements of training personnel, to communicate those requirements to the device designer, and to identify design shortfalls. The expressed judgments of the reviewers were positive, and suggestions were made by the reviewers that resulted in clarification of several feature descriptions. The reviewers were not asked to judge the utility of the guides during future testing of the F-16 simulator, since the device was not designed to comply with the descriptions contained in the guides.

USE BY TANK SIMULATOR PROJECT PERSONNEL

Although the guides were prepared specifically for use in the design of a fighter/attack aircraft simulator, their utility with respect to other types of simulators is also of interest. Development of a simulator for the U.S. Army's XM-1 tank was underway at the time of the present project. The simulator was intended for training-related research use, rather than for operational training, but its design included a number of instructional features similar to features of the F-16 simulator under development. Those design guides that describe instructional features relevant to the tank simulator requirements were reviewed with the researchers for whom that device was being developed. The purpose of these reviews was to assess the utility of the guides as a mechanism that would facilitate communication between the intended device users and the device developer with respect to simulator performance design requirements, and to clarify for the users which functions described in the guides could and could not be performed in the simulator as currently designed. Both uses of the guides appeared to have merit. Simulator features inconsistent with the users' needs were identified, and modifications to the device's design were initiated as a result of the reviews.

USE DURING OTHER AIRCRAFT SIMULATOR PROJECTS

Two additional simulator development projects in which the utility of instructional feature design guides could be assessed were underway

at the time the present report was being prepared. Both projects involved flight simulators for the U.S. Coast Guard: one for the HU-25A medium range search airplane, a twin-engine business-type jet, and the other for the HH-65A short range recovery helicopter. The guides developed during the present project which describe instructional features that are to be included in the Coast Guard simulators were rewritten where required to reflect the multi-crew configuration of each Coast Guard aircraft, their missions, the kinds of training intended, and the configuration of each of the simulators. The guides were then reviewed by Coast Guard simulator projects personnel to assure that the training described in the guides was consistent with the requirements of these personnel and with the manner in which they plan to employ the simulators during training. Specifications for the simulators were prepared to reflect the information in the guides. The guides were then annexed to the simulators' specifications to provide amplification and clarification of instructional feature design requirements identified in those procurement documents.

In responding to solicitations for the development of the two Coast Guard simulators, it is planned that each offeror will be required to indicate any function identified in the guides that cannot be provided through his proposed design approach. Design shortfalls thus identified will be subjects for clarification conferences between the offerors and Coast Guard training personnel. The purpose of these conferences, which may result in further revision of the guides or modifications to the proposed design approaches, will be to seek simulator instructional feature design alternatives that will allow the required instructional activities to be conducted in an efficient manner. Subsequent simulator acceptance testing activities related to the simulators' instructional features will examine whether each of the functions described in the design guides can be performed under the conditions prescribed for it.

APPENDIX

Simulator Instructional Feature Design Guides

Feature:

Record/Playback

Definition:

Record/Playback (R/P) is a simulator instructional feature that permits the instructor to replay a recent or immediately preceding segment of simulated flight. During a playback, all events which occurred as a consequence of pilot input to the simulator's controls will be reproduced without such inputs having to be repeated. The playback will repeat the cockpit control movements, cockpit instrument values, cockpit displays, motion cues, visual scenes, mechanical and aerodynamic sounds, and voice communications which occurred during the period of recorded time selected for replay.

The R/P feature continuously records the most recent segment of simulated activities. Recording occurs automatically whenever the simulator is being controlled (flown) from the pilot's station. Periods of Freeze, Demonstration, or control of the simulator from the IOS are not recorded except to the extent that may be required to establish initial conditions. The most recent period of training activity, e.g., five minutes (or all previous activity if less than five minutes of pilot-controlled flight have occurred), will be recorded and continuously available. Recorded flight may be accessed for playback in 10 to 15 second intervals up to the full time available, and access time to the beginning of any such interval must be rapid, e.g., within 15 seconds.

Purpose and Intended Use:

The purpose of the R/P feature is to enable the pilot to examine his own performance and to aid the instructor in critiquing pilot performance. R/P provides a faithful reproduction of pilot performance that can be examined in detail at a pace determined by the instructor, repeatedly if necessary, while that performance is simultaneously being reviewed by the pilot himself. Its use will permit relationships between pilot control inputs and system responses to be examined, and thus it can be employed with pilots having particular difficulty mastering a specific skill. The R/P feature will be used when new maneuvers or tasks are being trained and when instructor critiques are an important instructional activity. Its frequency of use will decrease as the pilots using the simulator become more proficient in the performance of required tasks.

The most frequent use of the R/P feature will follow an error or a less than satisfactory performance by the pilot. Rather than waiting until a post-training period debriefing to critique such performance, the instructor will interrupt the simulated flight to replay the performance in question. Using the recording as an aid, he will "debrief" the pilot at that time. Normally, the performance of interest

will be of short duration, so the time devoted to the playback will be brief. The duration of the recorded performance that is available is intended to permit the instructor a degree of flexibility in employing the R/P feature. He seldom will replay the entire recording, since to do so would tend to be an inefficient use of training time.

The Freeze function serves the same purpose when the R/P feature is in use as it does during any nonplayback mode of operation in that it "freezes" all parameters at the values which exist at the time Freeze is entered. Regardless of the prior activities, the instructor may end Freeze and (1) continue monitoring the playback in real time with synchronized audio; or (2) continue monitoring the playback in real or slow time without audio. Slow time is a condition in which one unit of real or recorded time is stretched to two units of playback time, i.e., activities are slowed down to facilitate monitoring them. While in freeze status, the instructor also may elect to terminate the playback and continue other instructional activities.

Function Descriptions:

ENTER. A playback may be accessed through controls located at the IOS at the option of the instructor or at the request of the pilot. There are two prerequisites: (1) there must have been a previous period of activity during which a recording was made; and (2) the simulator must be in a freeze status when the playback is selected.

SELECT INTERVAL. The instructor must select the beginning of the interval of recorded flight that he wishes to replay and must initiate the playback once the necessary initialization parameters have been established. Establishment of the initial conditions must not require more than approximately 15 seconds regardless of preceding instructional activities.

MONITOR. The playback will begin at the instant in time defined by the beginning of the recorded interval selected. During the playback, the pilot and instructor will monitor the simulator displays and controls, and appropriate instructional discussion may ensue. The playback will continue to completion of the recorded interval without interruption, change, or instructor or pilot input unless the instructor elects to change the playback by using Audio Off or Slow Time, interrupt the replay temporarily by using Freeze, or terminate it altogether as described below.

AUDIO OFF. The instructor may elect to replay the recorded simulator performance in real time without the recorded audio. Turning the audio off would permit him to discuss the recorded performance more freely with the pilot. During such activities, however, the audio will continue to maintain synchronization with the playback so that the instructor may reinstate the recorded audio at any time.

SLOW TIME. The instructor may elect to replay the recorded simulator performance in Slow Time. Slow Time would be used selectively by the instructor to replay segments of recorded activity in which events occur with considerable rapidity, and consequently the inter-task

relationships associated with such events are difficult to discriminate during real time. During Slow Time playback, there is no audio accompaniment, leaving the instructor free to interact verbally with the pilot. The instructor may return to a real-time playback rate (with synchronized audio on, if he wishes) at any time.

TERMINATE. The instructor may terminate a playback at any time or during a period of freeze. He frequently will do so, because the relatively brief segment of interest to him and the pilot will have been completed. They will not wish to monitor subsequent portions of the playback that are of little interest at the moment. When the playback is terminated before the end of the recorded segment has been reached, the simulation conditions existent at that time, rather than the conditions that define the end of the recorded segment, will obtain. The instructor may choose to allow the pilot to assume control of the simulated aircraft and "fly out" from these conditions.

COMPLETE. The instructor and the pilot may continue monitoring the playback until the end of the recording. When that point is reached, the conditions necessary for continuation of the interrupted simulator training flight from the point of the interruption will have been reestablished, and the simulator will automatically enter freeze status.

RESET. There will be times when the instructor wishes to terminate a replay and to continue the interrupted flight from the point of its interruption. The Reset function will permit the instructor to reset the simulation to the conditions existent at the time flight was interrupted, i.e., to the end of the recording. Such action will enable the pilot to continue the simulated flight as though there had been no interruption except Freeze. Resetting in the manner described from any point in the recording must not require excessive time, i.e., not more than approximately 15 seconds.

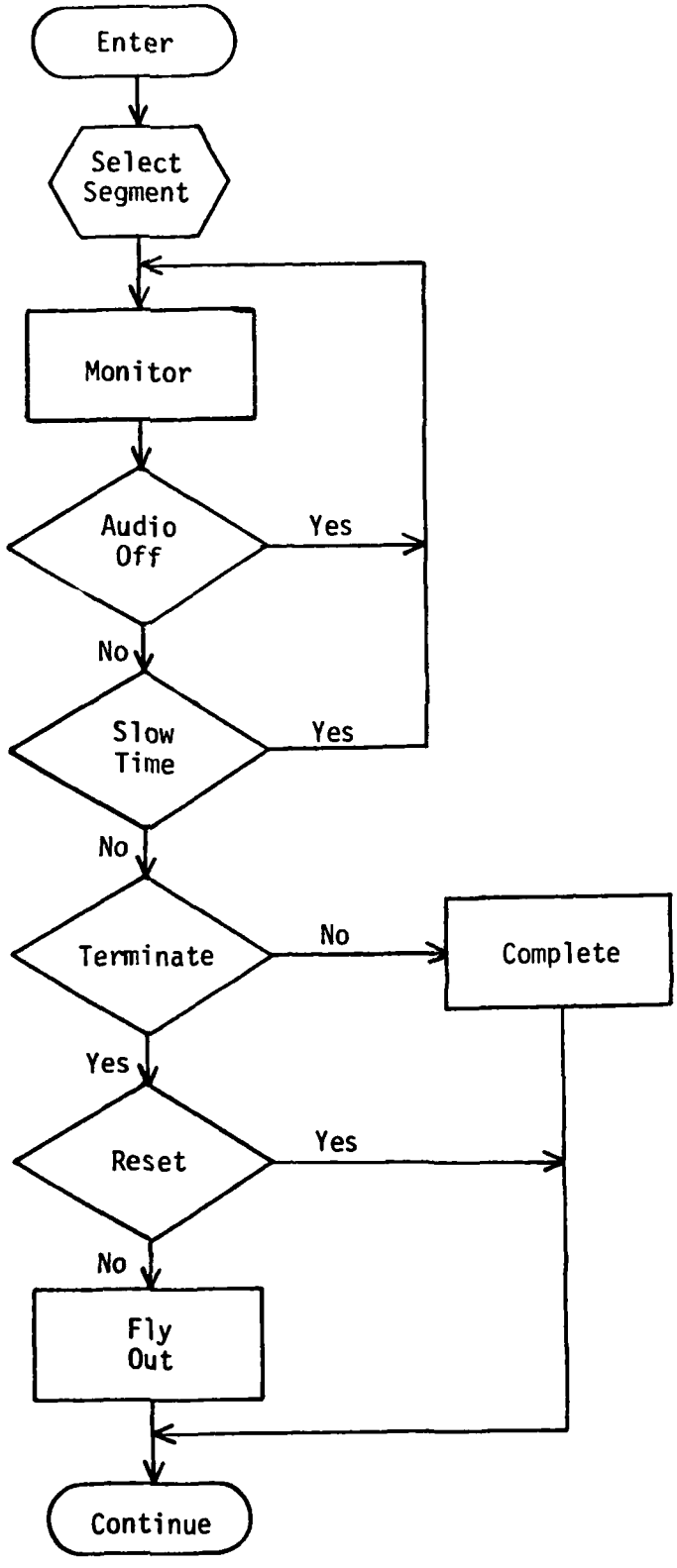
FLY OUT. There will be times when the instructor will wish a pilot to assume control of the simulated aircraft at a point that occurs during a playback and to "fly out" from that point rather than to continue to the end of the recorded segment. The Fly Out function will permit this to occur. Thus, the instructor will be able to terminate the playback and use the conditions then existent as conditions for further training. If the Fly Out option has been selected, however, the previously recorded flight may be lost from the point of flyout to the end of the recorded segment.

CONTINUE. Upon completing or terminating a playback, the instructor may exit the R/P feature and employ any other feature of the simulator in his process of instructing the pilot. Alternatively, he may continue reviewing the recorded activities by reentering the R/P feature and selecting the same or a different interval and initiating its playback. If he elects this latter course, he retains all options available during the initial playback, including the option to monitor the synchronized audio during real-time playback, except for any loss of recorded flight resulting from use of the Fly Out function. The time required to establish the necessary condition for reentering R/P at any selected interval must be brief, e.g., not more than 15 seconds.

Concurrent Events:

While a playback is being monitored--in real or slow time, with or without audio, in or out of Freeze--the instructor will be able to employ other simulator features to analyze the performance being replayed or to accomplish tasks that will enable him to undertake subsequent training activities more efficiently. That is, he will be able to perform activities that he could perform during the time the performance was being recorded. Thus, he may select displays, performance data summaries and scoring routines that will enable him to provide feedback and instructional guidance to the pilot, and he may index and search display data pages for information that will facilitate the subsequent setup and employment of other simulator features. He also will be able to employ other instructional features such as Remote Display, Hardcopy, and the Store function of the Store/Reset Current Condition feature. He will not be able to make changes in the simulation that would modify the playback, such as modification of the simulation parameters or insertion of a malfunction.

Feature Diagram:



Feature:

Store/Reset Current Conditions

Definition:

Store/Reset Current Conditions (S/R) is a simulator instructional feature that permits the simulation to be returned or reset to a set of conditions that existed at an earlier point in time. The conditions to which the simulation would be reset using this feature would have been selected when the simulator was initialized, or at the time of their occurrence during an instructional activity, and recorded or stored at that time for subsequent use. Selecting and storing such conditions will not interrupt or otherwise affect ongoing simulator activities. The stored conditions would be retained until replaced by other stored or designated initial conditions. Reset to a set of stored conditions can occur repeatedly.

Purpose and Intended Use:

The primary purpose of the S/R feature is to permit a pilot to return (or to be returned) to a previously encountered set of simulated conditions in order that he may repeat a maneuver or flight segment that he attempted earlier. The feature might also be used to provide a quick-reset capability that would enable an instructor or the pilot to reset the simulated aircraft to a previously designated set of initial conditions with minimum effort. A secondary purpose of the S/R feature is to facilitate the development of coherent sets of initial conditions that can be retained for use during subsequent periods of instruction.

The S/R feature provides a means of increasing the efficiency of the simulator instructional process by enabling the rapid and easy reestablishment of the exact conditions needed for a particular instructional activity. Thus, if the existent conditions associated with the beginning of a maneuver or maneuver segment through which the simulated aircraft may be flying are stored, the aircraft can be reset to those conditions without having to repeat the process of flying to them.

The storage of such conditions is accomplished through controls located at the IOS and in the cockpit. The existent conditions of the simulation may be stored without respect to other instructional activities, to the freeze status of the simulator, or to the position of any other IOS or cockpit controls. However, because operation of the S/R controls in the cockpit may be difficult while flying the simulator, the pilot will normally place the simulator in freeze status before exercising the Store function. The Store function may be exercised repeatedly, but the Reset function will always reset the simulated aircraft to the conditions existent at the most recent time the Store function was exercised. There is no restriction on the frequency of use of the Reset function.

During an instructional period in which the Store function has not been exercised, exercise of the Reset function will reestablish the simulator initial conditions most recently selected through controls associated with the initialization process. Each selection of an alternate set of simulator initial conditions during an instructional period will automatically result in the loss of previously stored conditions. Subsequent exercise of the Reset function before the Store function is exercised will result in the reestablishment of the most recently selected initial conditions set. Thus, activation of the Reset function will always restore the most recently selected set of simulation conditions, whether they were selected by exercise of the Store function of the S/R feature or through the simulator initialization process.

As with the Store function, the Reset function may be exercised from the IOS or the cockpit. Thus, a pilot responsible for his own instruction would be able to increase the efficiency of that instruction by frequently resetting to conditions appropriate to the particular task he might be practicing.

While the Store function can be exercised without regard to the freeze status of the simulator, the Reset function can be exercised only while in freeze status. This status is necessary during reset because of the likely discontinuity of the parameters of simulation involved in the simulated physical displacement of the aircraft.

Use of the S/R feature to develop initial condition sets for use during subsequent periods of instruction is a function that will take place when instructional activities are not in progress. When new or revised initial condition sets are required, they will be established by "flying to" the desired conditions, storing them, and entering a freeze status. The stored conditions would then be transferred into "permanent" storage in designated memory locations. In order to maintain control over the content of initial condition sets, however, designation of a memory location and transfer of the stored condition into permanent storage is a program development function and cannot routinely be accomplished through controls located at the IOS.

Function Descriptions:

ENTER. The S/R feature may be accessed through controls located at the IOS or in the cockpit at any time the simulator has been initialized for training or instructional exercise development purposes.

STORE INITIAL CONDITIONS. The process of initializing the simulator temporarily stores the selected initial conditions for subsequent reestablishment without repeating that process.

RESET INITIAL CONDITIONS. After initializing the simulator and before storing conditions that occur during its use, exercise of the Reset function will return the simulation to the most recently selected set of initial conditions. This function may be exercised repeatedly, but only when the simulator is in freeze status.

Store/Reset Current Conditions (continued)

STORE CURRENT CONDITIONS. When a set of simulation conditions is encountered to which the pilot or the instructor wishes to return subsequently, those conditions may be stored in place of the previously stored initial conditions. The Store function may be exercised repeatedly, but each exercise of it will erase previously stored conditions.

RESET STORED CONDITIONS. Exercising the Reset function after exercise of the Store function will reset the simulation to the conditions existent at the time the Store function was most recently exercised. This function may be exercised repeatedly, but only when the simulator is in freeze status.

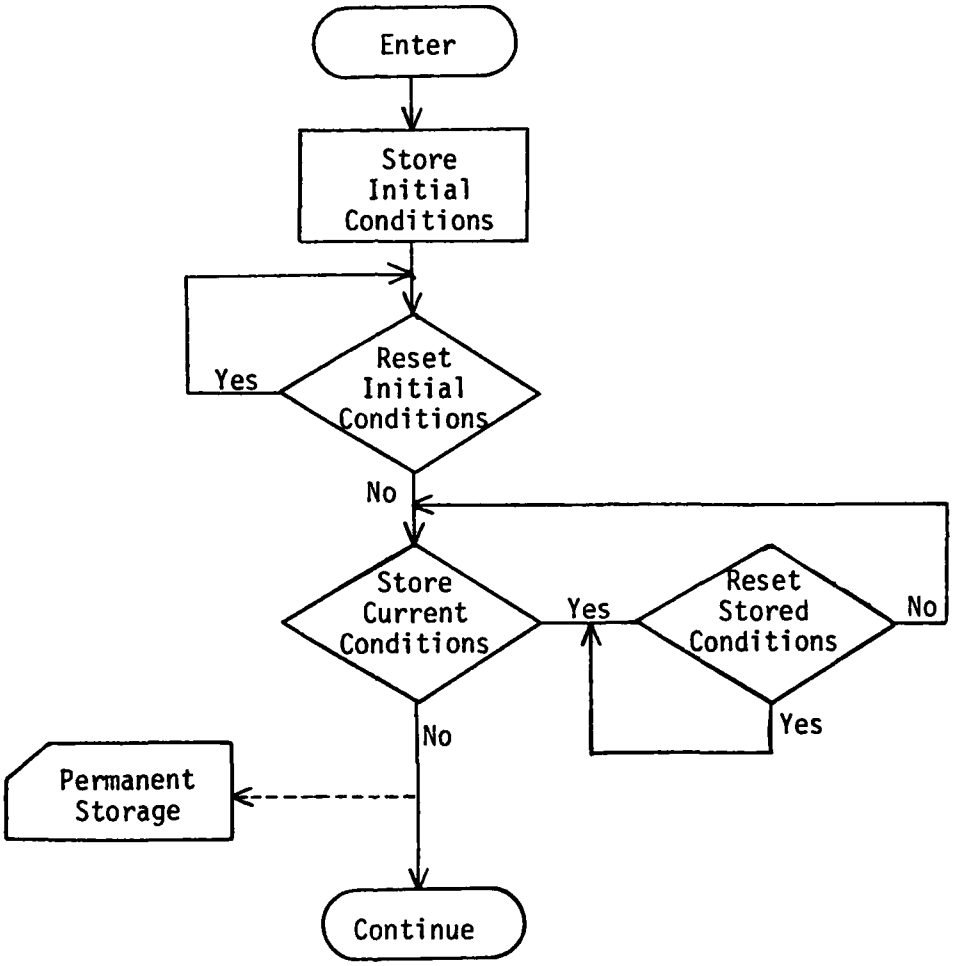
CONTINUE. After exercising any of the above functions, the instructional process may continue. Although a set of conditions is held in storage, no instructor or pilot interaction with the feature is necessary.

PERMANENT STORAGE. A temporarily stored set of conditions may be stored in a permanent location for use during subsequent periods of instruction. Designation of a storage location and effecting the storage is a program development function and cannot be accomplished during training.

Concurrent Events:

The Store function of the S/R feature may be used in conjunction with all other instructional features and without regard to the simulator's freeze status. The Reset function may be used in conjunction with all instructional activities, excluding playback of previously recorded segments of flight, except that the simulator must be in freeze status when it is exercised.

Feature Diagram:



Feature:

Remote Display

Definition:

Remote Display (RD) is a simulator instructional feature that permits alphanumeric and graphic data displayed on an IOS CRT to be displayed simultaneously to the pilot in the cockpit. The remoted display will appear on a display provided for that purpose or on an existing display provided primarily for other uses (e.g., visual system, HUD, or sensor scope).

Purpose and Intended Use:

The purpose of the RD feature is to enable the instructor at the IOS and the pilot in the cockpit to view displayed information simultaneously. The feature will be employed to facilitate communication between the instructor and the pilot, particularly when the communication involves reference to graphic or symbolic information. Any single CRT display reflecting pilot or simulated vehicle performance available at the IOS may be remoted for the pilot's viewing while it is being displayed at the IOS.

The RD feature will normally be employed when the simulator is in freeze status. It cannot be used when the simulated aircraft is being controlled by the pilot in the cockpit, since its use at such times could interfere with ongoing simulated activities. During playback of a previously recorded segment of simulated flight (i.e., Record/Playback or Demonstration), however, the instructor may employ the RD feature to enable the pilot to observe status information displayed on an IOS CRT and to correlate that information with vehicle performance.

Function Descriptions:

ENTER. The RD feature may be accessed through IOS controls at any time alphanumeric or graphic data are displayed on one or more IOS CRT displays and the simulator is in freeze status or recorded performance is being replayed.

SELECT DISPLAY. The instructor will select the display to be remoted to the pilot from among the alphanumeric or graphic displays he is using to monitor pilot performance.

REMOTE. The Remote function presents the selected display to the pilot in the cockpit. If the display is remoted to a CRT that is normally used for another purpose, it will displace the previously displayed information. The remoted information continues to be displayed on the IOS CRT.

REMOTE ANOTHER DISPLAY. The instructor may select and remote sequentially as many of the available IOS displays as he wishes in the manner described. He may also alternate between selected displays.

END REMOTE. When Remote is deactivated, the pilot's display is blanked or is returned to its primary purpose.

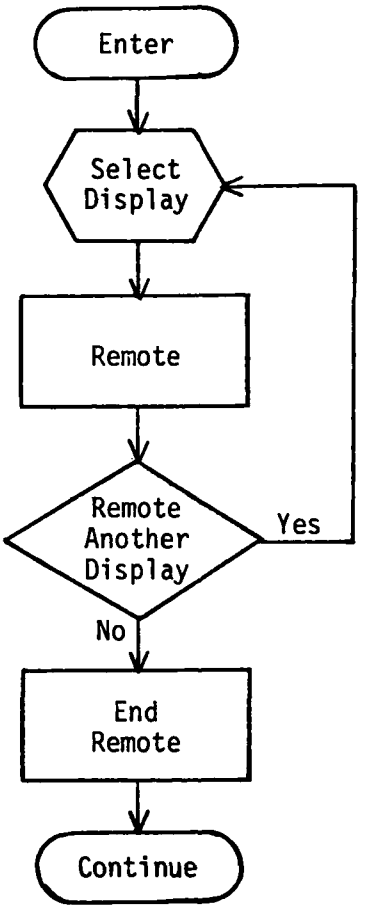
CONTINUE. After use of the RD feature the instructor and pilot may proceed with the instructional process with the simulation unaffected by the use of the RD feature.

Concurrent Events:

The RD feature may be used in conjunction with the Demonstration and the Record/Playback features or when the simulator is in freeze status. All simulator display and control functions operable during use of these features will function in their normal manner when the RD feature is in use.

Remote Display (continued)

Feature Diagram:



Feature:

Hardcopy

Definition:

Hardcopy is a simulator instructional feature that enables the instructor to reproduce on a paper medium alphanumeric and graphic data displayed on an IOS CRT. The feature provides a copy of those data as they exist at the time the reproduction is initiated by the instructor. Data permitting subsequent identification of the pilot and the instructional activity underway will appear on each copy generated by this feature.

Purpose and Intended Use:

The purpose of the Hardcopy feature is to provide the instructor a copy of perishable information displayed at the IOS. The copied display may be used by the instructor to compare the performance of a pilot at two points in time during a single instructional period, or over several such periods, to compare the performance of several pilots on similar flight tasks, to aid the instructor in subsequent review of a pilot's performance, and/or to provide objective information for permanent record purposes. The instructor may write notes on the copy generated by use of this feature as an aid to his subsequent use of the data copied. Use of the hardcopy feature will not affect any aspect of the simulation except for the generation of the copy. This feature may be used independently of other instructional activities in progress.

Although the IOS contains multiple data displays, only one can be copied at a time. The instructor usually will be satisfied to copy single displays or to obtain near-simultaneous copies of multiple displays by copying each one sequentially. However, should the instructor desire copies to be made of multiple displays occurring simultaneously, it would be necessary to preserve the displays until each can be copied by entering freeze status. The time required to obtain copies of more than one display or sequential copies of a single display will be limited by the time required to activate the appropriate IOS controls. The copy generation process may require additional time. Once generated, however, the copy will be available at the IOS for immediate use by the instructor.

Function Descriptions:

ENTER. The Hardcopy feature may be accessed through controls located at the IOS any time alphanumeric or graphic data are displayed on one or more IOS CRT displays.

COPY MULTIPLE DISPLAYS. Normally, the instructor will not require that copies be made of data occurring simultaneously on more than one

display. If simultaneous copies are desired, however, the simulator must be in freeze status.

FREEZE. Freezing the simulator interrupts all simulated activity and preserves the displays of status data as of the instant of freeze. The simulator must remain in freeze status until the last copy has been initiated.

SELECT DISPLAY. Through controls at the IOS, the instructor will select the display to be copied. It will be possible to select any one of the IOS alphanumeric or graphic displays. The simulator may, but need not, be in freeze status when the selection is made.

COPY. A display will be copied only by activation of controls at the IOS, and only the single selected display will be copied. An additional copy of the selected display may be made immediately thereafter, thus permitting a sequence of events presented on a single display to be copied.

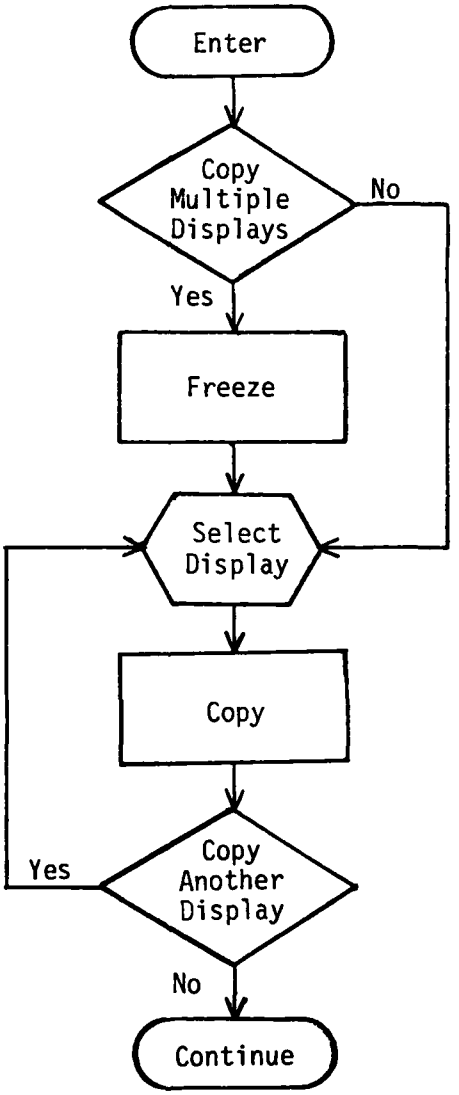
COPY ANOTHER DISPLAY. The instructor may copy sequentially as many of the IOS displays as he wishes in the manner described above.

CONTINUE. The simulated flight and related instruction will continue unaffected by the use of the Hardcopy feature except to the extent that the generated copy may be employed in the instructional process. If the simulator was placed in freeze status in order to preserve displayed information until it could be copied, that status must be ended before continuing.

Concurrent Events:

The Hardcopy feature can be employed concurrently with any simulated event or instructional activity, whether that event or activity is a consequence of instructor or pilot control input or of previously recorded input. The IOS controls related to the Hardcopy feature will operate independently of all other IOS controls.

Feature Diagram:



Feature:

Manual Freeze

Definition:

Manual Freeze (MF) is a simulator instructional feature that enables the instructor or the pilot to freeze or suspend ongoing simulated activity resulting from input to the aircraft's controls (in the cockpit and at the IOS), from recorded data, or from computer-generated data. During the period of suspension, the simulated conditions existent at the onset of MF will be preserved, and the suspended activity may be resumed at the option of the instructor or the pilot. Except for the primary flight controls, controls and displays at the IOS and in the cockpit will retain their normal function during use of this feature and may be employed to change the preserved conditions. During a period of freeze, cockpit avionics displays will reflect the fixed position of the simulated aircraft but will otherwise function normally in response to operation of the controls associated with such displays.

Purpose and Intended Use:

The primary purpose of the MF feature is to permit the interruption of the simulation so that other instructional or supporting activities may take place or to provide a break in the instruction. The secondary purpose of this feature is to provide a stable condition during periods in which the simulator is "on" but the cockpit may be unoccupied, thus allowing necessary setup or simulation modification functions to be performed through controls located at the IOS. Cockpit ingress/egress also will be possible during periods of freeze without concern for inadvertent movement of cockpit controls.

During the course of instruction, the instructor will employ the MF feature in conjunction with other instructional features. A modification to the simulation that involves a discontinuity in any parameter affecting flight will be effected only while the simulator is in a freeze status, e.g., repositioning of the simulated aircraft or substituting one external visual display scene for another (discontinuities involving visual displays will require that such displays be blanked to minimize distractions to the pilot). Instructional features that are incompatible with simulated flight under pilot control may be initiated only when the simulator is in a freeze status, e.g., Record/Playback and Demonstration. Likewise, use of the Remote Display feature, and the Hardcopy feature when simultaneous copies of multiple displays are desired, can occur only when the simulator is in freeze status. Use of other features, such as Malfunction Simulation, Automatic Malfunction Insertion, and Parameter Freeze, may be initiated without respect to the freeze status of the simulator, but the effect of these features upon the simulation will be

noted only when the simulation has resumed.

Although the frequency of use of the MF feature will vary as a function of the preference of the instructor, the relative skill of the pilot, and the simulated activity under way, the feature will be employed frequently. Therefore, ready access to it is important. When control of instructional activities is being exercised from the IOS, employment of the feature normally will be initiated and terminated by the instructor. When the pilot is engaged in a self-instructional activity, he may also initiate and terminate periods of freeze from the cockpit. To avoid confusion over whether the simulator is being or can be flown from the aircraft controls, the freeze status of the simulator must be made obvious to all participants in the instructional process at all times, regardless of whether its status was determined by the instructor, by the pilot, or otherwise.

Function Descriptions:

ENTER. The MF feature may be accessed at any time through controls located at the IOS and in the cockpit. Activation of these controls at either location will override any simulated activity in progress.

FREEZE. Using the MF feature to initiate Freeze requires positive action by the instructor or the pilot, followed by a clear visual indication in the cockpit and at the IOS that such action has been taken. The response of the simulator will be instantaneous.

INTERVENING ACTIVITIES. When the simulator is in freeze status, a variety of activities related to the instructional process and the convenience of the personnel involved may take place. For example, other instructional features such as Remote Display may be employed to facilitate the instructor's verbal interaction with the pilot, or the instructor and pilot may engage in a period of rest.

MODIFY SIMULATION. During any period in which the simulator is in freeze status, the instructor may modify the simulation by repositioning the aircraft, changing the atmospheric and visual environment, or changing the vehicle's stores configuration, in which case, upon subsequently ending the freeze status, the newly selected conditions will obtain. The only option available to the pilot through controls in the cockpit during a period of freeze, other than to end that period, is to reset the simulator to a previously stored set of conditions.

END FREEZE. When the purpose of the period of freeze has been met and it is desired that the simulation continue, the freeze status may be terminated through controls located at the IOS or in the cockpit. Positive action is required to end a period of freeze, and the response of the simulator will be immediate. When the period of freeze is to be ended by either the instructor or the pilot, the other individual will be alerted to the pending change so that he will be prepared to continue the simulation from the point of its interruption.

CONTINUE. Upon termination of the freeze status of the simulation, training activities will continue as appropriate.

Manual Freeze (continued)

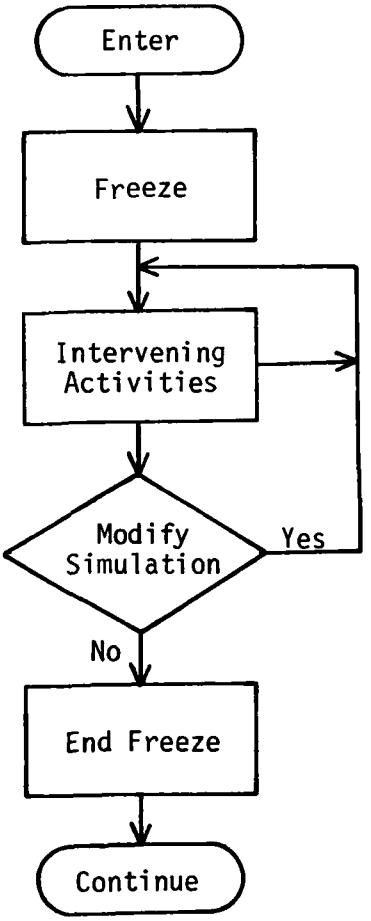
Concurrent Events:

A period of freeze may be initiated at any time simulation is in progress without respect to ongoing activities in the cockpit or at the IOS. The feature may be employed to interrupt recorded flight (i.e., during use of Record/Playback and Demonstration features) and during the development of automatic training exercises (e.g., Demonstration Preparation). The initiation or termination of a period of freeze may occur simultaneously with the employment of any other device feature.

When the simulator is in freeze status, operation of flight controls will not alter the status of flight of the simulated aircraft. Controls that alter the aircraft's configuration (e.g., flap position), the cockpit environment (e.g., information presented on the HUD or stations tuned on cockpit radios) or the external environment (e.g., the scene displayed outside the cockpit) will remain active. When the period of freeze is ended, the simulation will be fully responsive to the position of each flight control at that time. Therefore, positions incompatible with the existent simulated conditions will preclude ending a period of freeze until the necessary changes have been made in those controls (e.g., landing gear up when the aircraft is on the ground). Required changes in simulator controls must be made known to the instructor.

When the simulator is in freeze status, the motion-cueing devices will revert to and maintain a neutral position, and the visual display will retain the scene existent at the instant MF was initiated. All cockpit and IOS displays and controls associated with operation of the simulator, including simulator setup and shutdown and use of the device's instructional features, will be fully operable and will retain their normal function.

Feature Diagram:



Feature:

Automatic Freeze

Definition:

Automatic Freeze (AF) is a simulator instructional feature that automatically freezes or suspends ongoing simulated activity when predetermined conditions are met. The effects upon the simulation and upon the cockpit and IOS controls of an automatically initiated freeze are identical to those of a manually initiated freeze.

Purpose and Intended Use:

The purpose of the AF feature is to place the simulator in freeze status immediately upon the occurrence of specified events, and to do so without intervention by personnel at the IOS or in the cockpit. Three kinds of events may trigger the AF feature. They are: (1) entering a set of flight conditions that would be the equivalent of a crash in the aircraft being simulated, e.g., exceeding aircraft structural limits or impacting the surface at an excessive rate; (2) being impacted by surface-to-air or air-to-air weapons; and (3) encountering conditions that mandate placing the simulator in freeze status, e.g., preparing the simulator for an initial instructional activity or reaching the end of a period of recorded flight. Since the initiation of a freeze condition resulting from such events may not be expected, its onset must be called to the immediate attention of the instructor and the pilot.

The simulator may normally be released from freeze status at any time through positive action by the instructor or the pilot. However, in the case of an automatically initiated freeze resulting from the entry of the simulated aircraft into crash conditions, action must be taken to remove or overcome those conditions before the period of freeze can be ended. This may be done while the simulator is in freeze status by selecting and inserting a new set of initial conditions preparatory to beginning a new training activity, thus effectively removing the aircraft from the conditions that led to the freeze. Alternatively, the instructor may elect to "override" the crash conditions and permit the flight to continue from the point of crash. Should this latter alternative be elected, the simulated aircraft would "fly out" of the crash conditions following termination of freeze.

Crash conditions may be encountered frequently in training situations in which relatively inexperienced pilots are attempting to acquire skill at tasks involving unstable flight regimes or high performance maneuvers. In these situations, crash conditions might be encountered too frequently for efficient instruction to take place. In order to avoid such inefficiencies, the instructor might "override" future crashes until pilot proficiency improves, and thus permit the simulated aircraft to "fly through" conditions that otherwise would

result in a crash and the automatic initiation of a period of freeze. If the override function was selected before crash conditions were encountered, the simulated flight would continue uninterrupted, but the displays at the IOS would reflect the fact that conditions equivalent to crash had been met. The instructor would retain the option to remove the override function or to employ the Manual Freeze feature at any time.

A similar situation exists with respect to the automatic initiation of freeze status when the simulator's weapons-scoring algorithm determines that the simulated aircraft has received a lethal round (or number of rounds) from an enemy weapon, i.e., "own aircraft" has been "killed." When this occurs, the simulator will enter freeze status automatically and will remain in that status until it is ended by positive action from the IOS. As with the crash situation, in the kill situation the instructor may remove the kill conditions by selecting a new set of initial conditions and resetting the simulator for the next training exercise. Alternatively, he may override the kill conditions (including any aircraft system malfunctions that may have been simulated to indicate nonlethal hits) and, by ending the freeze status, allow flight to continue from the point of interruption. As with crash, the instructor also may elect in advance to override the AF feature with respect to the hit-kill algorithm in order to avoid too-frequent interruptions for a relatively unskilled pilot. When Override is elected in advance of the event's occurrence, the effects of being hit, other than aircraft degradation and/or freezing the simulation, will nonetheless occur, e.g., sounds and weapons signatures will occur, and scoring and status information will be displayed at the IOS. The instructor, in advance and without regard to his election concerning crash conditions, may elect to override or not override kill conditions. Conversely, he may do the same with respect to crash conditions.

The other events which automatically initiate freeze status relate to administrative aspects of the simulator instructional process and provide an interruption in the simulation at points at which a decision must be made concerning the next instructional activity. No AF override function is appropriate with respect to these events, because their occurrence indicates a choice point at which a different activity must be initiated if the simulation is to continue. Such an event occurs when the simulator is initially made ready for use at the beginning of a period of instruction and at the end of a segment of recorded flight, e.g., upon completion of a Demonstration or a selected interval of Record/Playback.

Function Descriptions:

ENTER. The AF feature is accessed automatically as a consequence of the occurrence of a crash event, a kill event, or an event that requires instructor intervention before the instructional process can continue.

CRASH CONDITIONS. The occurrence of flight conditions analogous to those that would constitute a crash in the aircraft simulated will be recorded as a crash in the simulator displays.

Automatic Freeze (continued)

CRASH OVERRIDE. If the instructor wishes to avoid interruption to the instructional process should crash conditions be encountered, he may elect to override those conditions prior to their occurrence. If he has so elected in advance, the simulator will "fly through" all crash conditions that may be encountered, and instructional activities in progress will continue uninterrupted. The Override function will not affect the display of information concerning the occurrence of the crash event at the IOS, however.

OTHER CONDITIONS. Conditions other than crash or freeze that automatically initiate a freeze status are: (1) preparing the simulator for an initial instructional activity, or (2) reaching the end point of a period of previously recorded flight.

KILL CONDITIONS. When a programmed scoring algorithm indicates that hostile ground or airborne weapons have "killed" the simulated (own) aircraft, the event will be recorded as a kill in the simulator displays, and sound and visual indications of being hit will be presented to the pilot.

KILL OVERRIDE. If the instructor wishes to avoid interruption to the instructional process should kill conditions be met, he may elect to override those conditions prior to their occurrence. If he has so elected in advance, the simulator will "fly through" all kill conditions that may be encountered, and instructional activities in progress will continue uninterrupted. The Override function will not affect the cockpit sounds and visual indications of being hit or the display of information concerning the kill event at the IOS, however.

FREEZE. When the prescribed conditions for the automatic initiation of a period of freeze are met (and Override, if appropriate, has not been elected in advance by the instructor), the simulator will enter a freeze status. It will remain in that status until action is taken from the IOS to terminate that status. While in a freeze status that has been initiated automatically, the instructor and the pilot may engage in the same activities that are available to them during periods of manually initiated freeze, and the same restrictions obtain.

OVERRIDE. If the freeze status was initiated because of the occurrence of crash or kill conditions, those conditions must be removed or "overridden" before simulated flight can continue. The Override function, when elected following the occurrence of a crash or kill, will permit the interrupted flight to begin again from the point of interruption when the freeze status is removed. The records of the occurrence of those events on the IOS displays will be retained, however. If Automatic Freeze resulted from events other than the occurrence of crash or kill, the Override function will not be required before the simulator can be released from freeze status.

END FREEZE. The freeze status may be terminated through controls located at the IOS or in the cockpit. Positive action is required to end a period of freeze, and the response of the simulator will be immediate. When the period of freeze is to be ended by either the instructor or the pilot, the other individual will be alerted to the

pending change so that he will be prepared to continue the simulation from the point of its interruption.

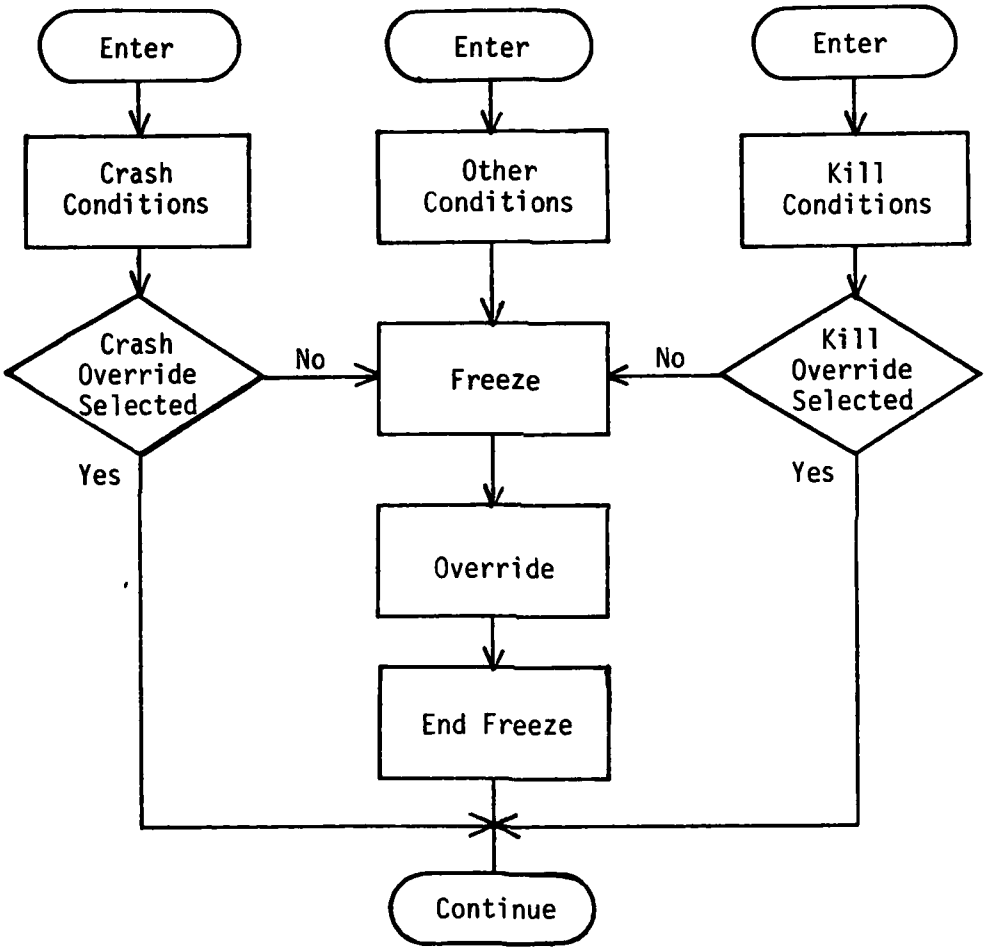
CONTINUE. Upon terminating the freeze status of the simulation, or if the Crash or Kill Conditions were overriden in advance, training activities will continue as appropriate.

Concurrent Events:

With respect to concurrent events, no distinction exists between automatically and manually initiated periods of freeze. For a discussion of other features of the simulator that may be employed concurrently with AF, see the description of the Manual Freeze feature.

Automatic Freeze (continued)

Feature Diagram:



SIMULATOR INSTRUCTIONAL FEATURE DESIGN GUIDE

Feature:

Parameter Freeze

Definition:

Parameter Freeze (PF) is a simulator instructional feature that enables the instructor to freeze one or more of the simulator flight parameters to its current value. When a parameter is in freeze status, all other parameters will be unaffected. All simulator performance and the displays at the IOS will reflect the fixed value of the frozen parameter, however.

The parameters that can be frozen by the instructor are limited to those provided in the simulation. These parameters will include aircraft position, individual rates of directional and angular movement, orientation in space, and fuel and expendable stores on board. The status of all frozen parameters will be indicated prominently on relevant IOS displays and in all records of measured pilot performance.

Purpose and Intended Use:

The primary purpose of the PF feature is to enable the instructor to reduce the difficulty to the pilot of the task being performed. Using the PF feature, this could be done by freezing one or more parameters of flight, thus reducing the number of parameters demanding the pilot's attention. Such an approach might be employed to simplify aircraft control when a pilot is experiencing difficulty developing the complex skills required to fly the simulated aircraft, or while the pilot acquires skills at associated tasks such as tracking a missile on a target or learning to operate on-board avionics and associated displays. When pilot performance is being measured automatically, use of the PF feature will be displayed prominently in all data displays and recordings to indicate that the task has been made easier to perform.

A secondary purpose of the PF feature is to facilitate the administration of training involving expendable resources, i.e., fuel and weapons stores. By freezing these parameters, training can proceed without interruption for the purpose of restoring expended resources. The effect would be to provide an inexhaustable supply of fuel and/or weapons stores.

A parameter may be frozen without respect to whether the simulator is in freeze status. Thus, a parameter frozen while the simulator is in freeze status will remain in freeze status when the simulator freeze is ended. While the feature will be employed sparingly, timing of the initiation of a period of freeze for a selected parameter may be important to the instructor, and the process cannot be lengthy or difficult.

Function Descriptions:

ENTER. The PF feature may be accessed through controls located at the IOS at any time except when a previously recorded activity is being replayed.

SELECT PARAMETER. The instructor may select any one (at a time) of the designated parameters to be placed in or released from freeze status.

FREEZE PARAMETER. The selected parameter will be frozen at the value existent at the moment its freeze status is initiated and will retain that value until the instructor ends its freeze status regardless of the instructional activities in progress.

RELEASE FROZEN PARAMETER. The freeze status of a selected parameter will be ended immediately upon the positive action of the instructor. If the simulator itself is in a period of freeze when such action is taken, the parameter will remain frozen until simulator Freeze is ended.

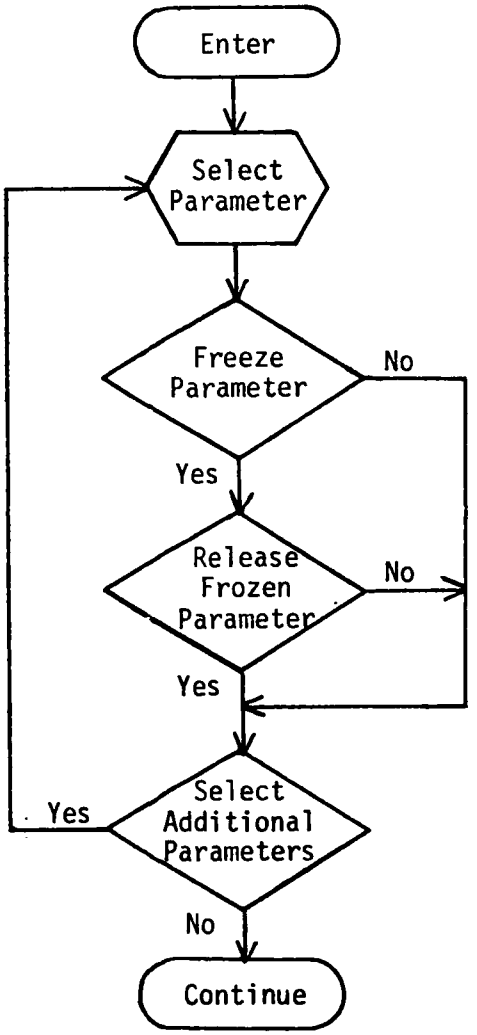
SELECT ADDITIONAL PARAMETER. The instructor may selectively freeze and/or release from freeze additional parameters in the manner described above, one at a time, until all available parameters have been frozen, or all previously frozen parameters have been released.

CONTINUE. The instructional process will continue with the parameters selected by the instructor in a freeze status or with such status ended. The instructor may reenter the PF feature at any time to end the freeze status of previously frozen parameters.

Concurrent Events:

The PF feature may be employed in conjunction with any ongoing training activity except those involving replay of a previously recorded segment of simulated flight (i.e., Record/Playback and Demonstration). It may be used during the development of automatic training exercises (e.g., Demonstration Preparation). Except to the extent that specific controls and displays involved in the execution of PF functions may be time shared with other simulator features (e.g., accessing data), the employment of this feature can take place concurrently with the employment of other simulator features.

Feature Diagram:



SIMULATOR INSTRUCTIONAL FEATURE DESIGN GUIDE

Feature:

Demonstration

Definition:

Demonstration (Demo) is a simulator instructional feature that consists of a prerecorded aircraft maneuver, or series of contiguous maneuvers, that provides a model of the desired performance of the maneuver being demonstrated. The Demo reproduces all simulated flight conditions and aircraft performance that occurred when the maneuver was originally recorded, including appropriate actuation of cockpit instruments, indicators, and flight controls; motion system movement; visual display scenes; and mechanical and aerodynamic sounds. A Demo includes a synchronized audio briefing, explanation, and instructional commentary designed to facilitate the pilot's subsequent performance of the maneuver.

The content of a Demo is not necessarily limited to execution of the maneuver(s) being demonstrated. A Demo may include repetitions of the entire maneuver or of any one or more of its segments, segments presented in slow time, and pauses, each with unique instructional commentary, whenever such variations in format of presentation may facilitate an understanding by the pilot of the associated performance requirements.

Demos may be divided into segments that correspond to significant parts of the maneuver being demonstrated or to events in the Demo itself. Each such segment is independently addressable from the IOS. Thus, each segment provides a "mini Demo" that addresses a particular aspect or portion of the maneuver being demonstrated.

Purpose and Intended Use:

The purpose of the Demo feature is to provide standardized instruction in the performance of difficult and/or complex aircraft maneuvers or series of contiguous maneuvers. The content and format of that instruction may vary significantly from one Demo to another, but Demos normally illustrate idealized performance, identify the significant cues and discriminations the pilot must learn to make in executing a maneuver, and provide other instructional commentary that may facilitate task mastery. A properly prepared Demo will aid the pilot in the acquisition of both knowledge and skills associated with performance of the maneuver demonstrated.

Demos normally will be used by the instructor to introduce a new maneuver to the pilot, and the pilot will observe the entire Demo without interruption before attempting to perform the maneuver in the simulator. The instructor might wish to repeat all or a portion of the Demo immediately, or after the pilot has attempted to perform the

maneuver. Alternatively, the instructor might re-present the Demo or one or more of its segments for the further instruction of a pilot who may find the maneuver particularly difficult to understand or to perform correctly. The instructor may elect to re-present only a segment on which the maneuver is recorded in slow time or in which a particular explanation is included, or he may repeat the entire Demo or a segment of it with the accompanying instructional commentary off so that he can provide his own commentary.

Function Descriptions:

ENTER. A previously developed Demo may be accessed through controls located at the IOS at any time during simulator training. A Demo can only be accessed when the simulator is in freeze status.

SELECT SEGMENT. The instructor must select the Demo and the segment of that Demo (usually the first) to be presented, and he must initiate its presentation once the necessary initial conditions have been established. Establishment of the initial conditions for any Demo segment must not require excessive time, e.g., not more than 30 seconds.

MONITOR. Once initiated, the instructor and pilot will monitor the Demo. The Demo will continue to its completion without interruption, change, or instructor or pilot input unless the instructor elects to turn the audio off, interrupt the Demo temporarily, or terminate it altogether. The instructor may temporarily interrupt the Demo at any time by initiating a period of freeze in order to discuss some aspect of it with the pilot or to engage in some other instructional activity. Regardless of prior activities, the instructor may terminate the period of freeze and continue monitoring the Demo with or without audio accompaniment until its final segment has been completed. Alternatively, he may terminate the Demo at any time and initiate another instructional activity.

AUDIO OFF. The instructor may elect to monitor the Demo without audio or to substitute his own instructional commentary for that provided with the Demo for any one or more of the segments. Turning the audio off will enable him to do this. During such periods, however, the audio will continue to maintain synchronization with the Demo so that the instructor can reinstate the recorded instructional commentary at any time.

TERMINATE. The instructor may terminate the Demo at any point after its initiation rather than complete it. When a Demo is terminated, the simulated conditions existent at that time, rather than the ones that define the end of the Demo, will obtain. From those conditions, the pilot may assume control of the simulated aircraft and "fly out."

COMPLETE. Unless the instructor intervenes, the Demo, once initiated will continue until its final segment has been completed. When that end point is reached, the simulator will automatically revert to a freeze status with all simulation parameters remaining at the values which define the end point of the Demo.

Demonstration (continued)

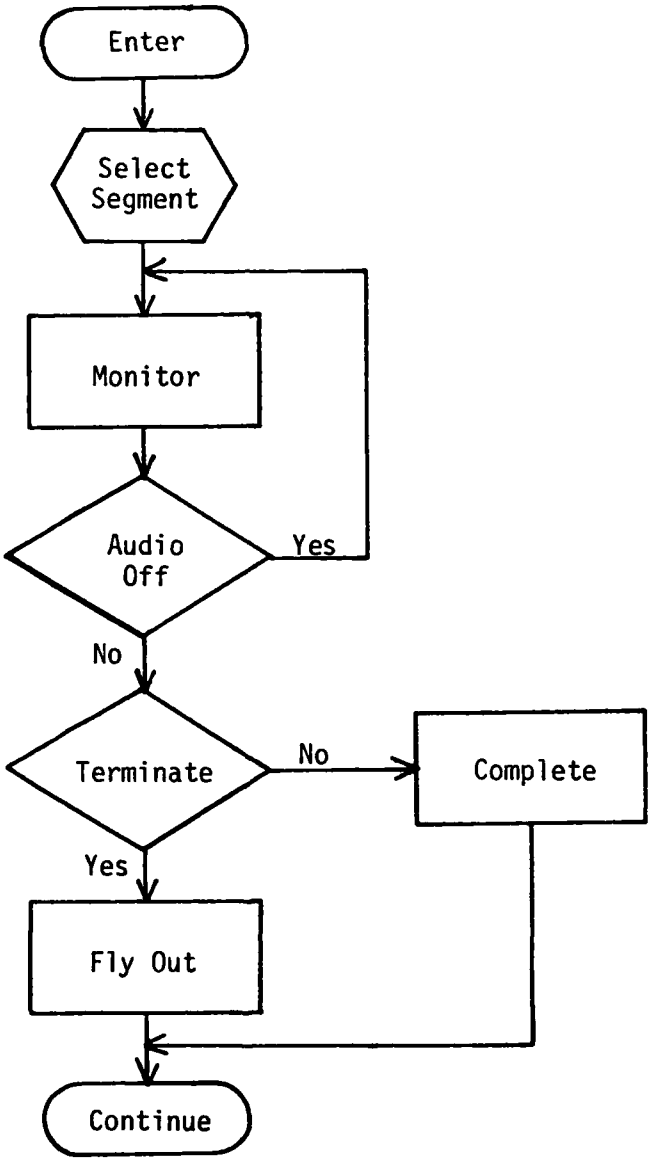
FLY OUT. There will be times when the instructor wishes the pilot to assume control of the simulated aircraft when a Demo has been terminated and to "fly out" from that point. The Fly Out function will permit this to occur.

CONTINUE. Upon completion or termination of the Demo, instructional activities will continue as appropriate. The instructor may reenter the Demo feature in order to repeat the same or another recorded Demo or any Demo segment by selecting the desired Demo and segment and repeating the process described above. If he elects this latter course, he retains all options available during the initial Demo presentation, including monitoring the synchronized audio with its instructional commentary. The time required to re-enter the Demo feature at the beginning of any segment should be brief, e.g., not more than 30 seconds, regardless of the point of termination of a Demo.

Concurrent Events:

While a Demo is in progress, the instructor may interact verbally with the pilot in order to contribute to the pilot's understanding of the maneuver(s) demonstrated. He may access previously generated performance data summaries that will enable him to provide verbal feedback to the pilot concerning his prior performance of the maneuver being demonstrated, and he may index and search data display pages for information that will facilitate the subsequent setup and employment of other simulator instructional features. He may also employ the Remote Display and Hardcopy instructional features, and he may use the Store/Reset Current Conditions feature to store conditions to which he may wish to reset upon completion or termination of the Demo.

Feature Diagram:



Feature:

Demonstration Preparation

Definition:

Demonstration Preparation (Demo Prep) is a simulator instructional feature that enables a simulator instructor to prepare a Demonstration (Demo) for repeated use during subsequent periods of pilot training.

Purpose and Intended Use:

The purpose of the Demo Prep feature is to permit Demos to be prepared by recording a period of performance in the simulator, modifying that recording to enhance its instructional value, and adding an expository or instructional commentary. The skills required to prepare a Demo using this feature are those normally found among simulator instructors who are pilots, and no additional technical training or computer programming skills are required. Nevertheless, it is expected that only designated instructors will prepare Demos in order that control may be exercised over their content and format.

Recording a Demo in the simulator will normally be preceded by the development of a scenario for the Demo. The scenario will identify the simulated conditions under which the maneuver(s) of interest will be flown, the number of repetitions of all or designated portions of the maneuver that are to be included in the completed Demo, where Pauses are to appear, and which segments are to be presented in slow time. The scenario also will identify the beginning of each Demo segment that is to be directly accessible by the instructor. A script of the planned instructional commentary will be prepared for the scenario. The script will be edited to assure that proper timing will be maintained between the content of the Demo and the commentary.

Following development of the scenario with its accompanying audio commentary, the Demo described in it will be developed by flying the simulated aircraft through the maneuver or series of maneuvers to be demonstrated while the flight is being recorded. While making the recording, the instructor (with the assistance of a second instructor located in the cockpit) would make use of the simulator's other instructional features such as Manual Freeze, and Store/Reset Current Conditions, as often as necessary to obtain a "model" performance of the maneuver being flown. This process may be repeated until the instructor is satisfied that the maneuver has been flown to the required standards. If the scenario requires that the Demo include more than a single repetition of the maneuver, as usually will be the case, the recording process will be repeated as many times as may be required.

Upon completing the recording of the maneuver, the instructor will "edit" it in accordance with the scenario by inserting pauses when

extended instructional commentary might be required or by "stretching" to slow time parts of the maneuver which occur too rapidly in real time for the pilot to be able to see important task interrelationships. He then would add Demo segment identifiers that will permit direct access to the beginning of individual segments when the Demo is employed in the instructional process.

Finally, using the script prepared for that purpose, the instructor will add the prepared instructional commentary to the recorded Demo. Recording the audio, which would normally be done while the newly prepared Demo is being replayed and monitored, will require careful attention--and possibly several practice trials--to synchronize the commentary with the instructional events being commented upon.

Because humans have limited attention spans and short-term recall abilities, the more effective Demos will tend to be relatively brief. The subject matter of Demos will consist of complex individual maneuvers or rapidly occurring series of maneuvers of which verbal descriptions alone might not provide enough information for pilots to learn rapidly to perform them. It is not expected that Demos will be prepared to illustrate mission segments in which individual maneuvers are separated by extended periods of relatively simple aircraft control tasks. For these reasons, most Demos, including those which contain Pauses and Slow Time segments, will be brief, i.e., of less than five minutes duration. Long Demos would be counterproductive in most instances and should not be prepared.

Function Descriptions:

ENABLE. Preparation of a Demo is a function that cannot be performed while instruction is in progress. To assure preservation of previously prepared Demos and to exercise administrative control over preparation of new ones, the Demo Prep feature must be intentionally enabled.

SET UP SIMULATOR. Setting up the simulator for the task of preparing a Demo, except for the necessary feature enablement, is comparable to setting it up for an instructional activity. Initial condition parameters which define the flight environment and the aircraft position and status must be selected and inserted. After this has been done, the simulator may be flown just as during a period of simulator instruction, and the instructional activity control features of the simulator normally available during such training may be used in preparing the Demonstration.

RECORD MANEUVER. Upon release from freeze status, the simulator performance will be recorded as flown. The instructor making the Demonstration recording may reestablish the previously selected initial conditions, or a different set of conditions as may be required, to produce a Demonstration consistent with the scenario. He may erase and re-record (i.e., record over) maneuver records that, upon review, he judges not to be satisfactory, and/or he may record numerous satisfactory trials sequentially until he has the number of satisfactory trials and variations of trials his scenario requires.

RECORDING COMPLETED. The recording and replay processes described above will be continued until the instructor has assembled the necessary examples of the maneuver that is the subject of the Demo being developed.

EDIT. When the recording process has been completed and the instructor is satisfied with the results, the recording will be edited to insert pauses and periods of slow time as described below.

ADD PAUSE. The instructor will play back the recorded maneuver, and, at points during the playback indicated in the scenario, he will insert periods of pause. During these periods, the Demo will continue to replay, but the simulated events will be in a suspended or "stop-action" status. Suspending these simulated events without stopping the Demo will permit the later recording of a more lengthy commentary explaining the event than would be possible without pauses. A pause may be of any length within the limits of playback time permitted for a Demo.

CHANGE TO SLOW TIME. Segments of the recorded maneuver may be "stretched" from real time to slow time so it will be easier for a pilot to monitor in greater detail performance being demonstrated. This stretching will be done, in accordance with the previously developed scenario, by replaying the portion of the maneuver to be stretched while the Change to Slow Time function is exercised. The length of the segment changed to slow time is limited only by the total time available for that Demo.

ADD SEGMENT IDENTIFICATION. After all pauses have been entered and slow time conversions have been made, the instructor will replay the Demo (which will now be at its full length) and divide it into independently addressable segments by "flagging" the points at which each such segment is to begin. These "flags" will be located in accordance with scenario specifications and will generally be at the beginning and/or at the end of pauses and slow time segments, and at the beginning of complete cycles of the maneuver being demonstrated.

ADD AUDIO. The final task of the instructor preparing a Demo will be to add the instructional commentary. This will be done by reading the script prepared during development of the Demo scenario onto a synchronized recording medium while the Demo is being replayed and monitored.

PERMANENT STORAGE. When the Demo has been prepared and reviewed by the instructor, and he is fully satisfied that it will provide the instruction intended (i.e., that no further editing or re-recording is required), it will be stored with other Demos for use during subsequent periods of instruction.

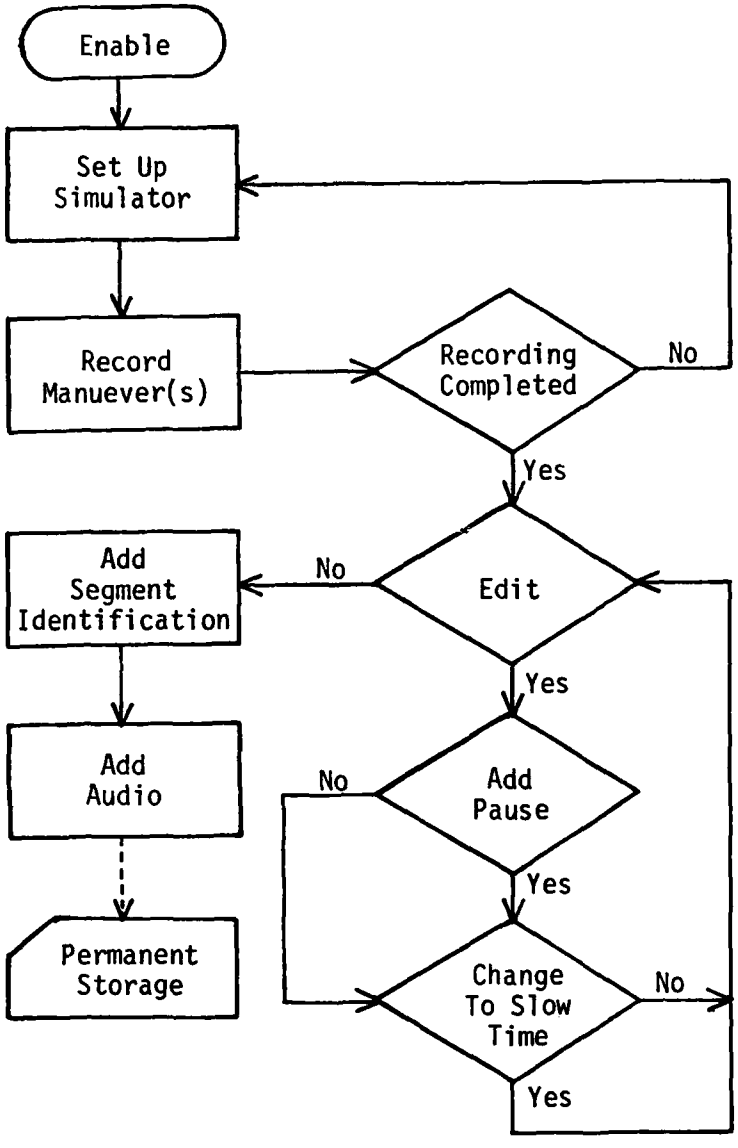
Concurrent Events:

While a Demo is being prepared, all simulator controls normally available during periods of instruction will retain their normal functions. These controls may be used to create and modify conditions

and events that will be included in the recorded Demo. Thus, the instructor may employ the Parameter Freeze or Store/Reset Current Conditions features, or he may change visibility on the visual display or activate hostile weapons. He also may employ the Hardcopy and Remote Display instructional features and the performance measurement and data summary capabilities of the simulator to examine the maneuver he has just recorded in order to determine its adequacy for his instructional purposes.

Demonstration Preparation (continued)

Feature Diagram:



Feature:

Malfunction Simulation

Definition:

Malfunction Simulation (MS) is a simulator instructional feature that enables the instructor to fail, partially or totally, a simulated aircraft component or to introduce an abnormal aircraft condition. When such a failure is inserted into the simulation, the consequences will duplicate the consequences of a corresponding failure in the aircraft simulated. Actions taken by the pilot in the simulator following insertion of a failure will have the same consequences as would be experienced under corresponding circumstances in the aircraft. The malfunctions that can be simulated will consist of component failures or abnormal conditions likely to occur during operation of the aircraft on the ground or in flight during the useful life of the aircraft, and for which an appropriate response by the pilot is required in order to complete a mission, avoid further aircraft degradation, or continue flight until a landing can be made. The instructor may insert or remove a simulated malfunction, but he may not affect its programmed characteristics.

Purpose and Intended Use:

The purpose of the MS feature is to enable the instructor to simulate the occurrence of component malfunctions and failures so that the pilot may be trained to determine that an abnormal condition has occurred, identify the condition, and take the prescribed corrective or compensating action. Since the simulator provides a safe environment in which such training can take place, it will be used frequently and in conjunction with all other instructional features of the simulator not involving recorded performance, and it will provide the only environment in which training associated with the most hazardous malfunctions can take place. For this reason, malfunction-compensating skills developed in the simulator must transfer intact and without further training to the aircraft. All cues that are associated with the malfunction in the aircraft and are detectable by the pilot are necessary to such transfer and must be represented in the simulator.

Function Descriptions:

ENTER. The MS feature may be accessed through controls at the IOS at any time during the conduct of training except when a previously recorded activity is being replayed.

SELECT MALFUNCTION. The instructor may select any one (at a time) of the malfunctions or abnormal conditions included in the simulation to be inserted during the current training period, or to be removed if the malfunction has already been inserted. The simulator need not be in a

freeze status for the selection to be made.

INSERT MALFUNCTION. A selected malfunction may be inserted into the simulation at any time following its selection provided another malfunction has not been selected. (Selection of a second malfunction before the first has been inserted would cancel the earlier selection.) Procedurally, the instructor will select a malfunction for insertion shortly before he wishes to employ it, will wait for a precise moment or event to occur, and will then insert it. Thus, he will exercise positive control over the use of simulated malfunctions in the training process. Once inserted, the malfunction will occur in the manner prescribed for it in the simulation program. An inserted malfunction will remain in effect until the end of the training period, until cleared by pilot action, or until the instructor removes it from the simulation. The instructor may elect not to insert a selected malfunction, but instead he may simply continue the instructional process.

SELECT ADDITIONAL MALFUNCTION. Some training activities will involve the simulation of multiple malfunctions. This might be done in order to train pilots to cope with complex degraded situations they are likely to encounter operationally or as a means of increasing simulator training difficulty for the more capable pilot. Therefore, additional malfunctions may be inserted by repeating the functions described above. Up to five malfunctions may be inserted, one at a time, in this manner. As an aid to the instructor, the simulator will display a list of all malfunctions that have been inserted and not subsequently removed during a training activity.

REMOVE MALFUNCTION. There will be times when the instructor will want to remove or delete from the simulation one of the previously inserted malfunctions. This situation might occur because the pilot has unintentionally been overloaded with malfunctions or because the instructor wishes to introduce other malfunctions without the continuation of one or more of the previously inserted ones. The instructor may select any previously inserted malfunction for removal. The simulator need not be in freeze status when the selection is made. When one or more malfunctions has been removed, the simulation is fully restored to the status that existed prior to the insertion of the removed malfunction. However, in carrying out the procedural tasks necessary to cope with the malfunction's insertion, the pilot may have placed switches and controls in positions incompatible with or inappropriate to the situation which obtains following its removal. Therefore, it is necessary that the instructor be alerted automatically to any such inconsistency and be provided the information that can lead to its correction. The removal of a malfunction does not affect any other malfunctions that may be in effect.

REMOVE ALL MALFUNCTIONS. This function permits the instructor to remove at one time all malfunctions currently in effect. Exercising this function permits the instructor to respond rapidly to a training situation that is deteriorating because of pilot overload, or to "clear" the simulation of malfunctions so that other instructional activities may take place.

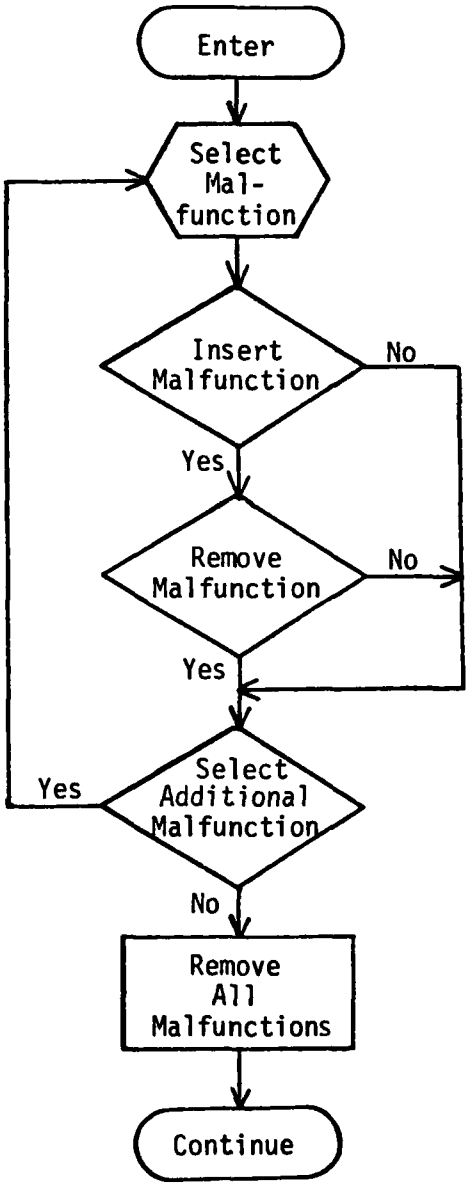
CONTINUE. Following exercise of one or more of the above functions the instructor will terminate his interaction with the MS feature and the instructional process will continue. Malfunctions that have been inserted and not removed will remain in effect as instruction continues.

Concurrent Events:

The MS feature may be employed in conjunction with any ongoing training activity except those that involve replay of a previously recorded segment of simulated flight (e.g., Record/Playback and Demonstration). It may be used in conjunction with automated training features that do not involve previously recorded simulator performance (e.g., Automatic Malfunction Insertion). In addition, the MS feature may be used during the development of automatic training exercises (e.g., Demonstration Preparation). Except to the extent that specific controls and displays involved in the execution of MS functions may be time shared with other simulator functions (e.g., indexing data), the employment of this feature can take place concurrently with the employment of other simulator features.

Malfunction Simulation (continued)

Feature Diagram:



SIMULATOR INSTRUCTIONAL FEATURE DESIGN GUIDE

Feature:

Automatic Malfunction Insertion

Definition:

Automatic Malfunction Insertion (AMI) is a simulator instructional feature that automatically inserts malfunctions or failures of simulated aircraft components in response to previously selected conditions expected to occur during an instructional activity. These contingent conditions include events such as reaching a specified altitude or airspeed, passing a geographic position, releasing a weapon, exceeding a time limit, or any combination of such events. When the specified insertion contingencies have been met, the malfunction will occur in the manner programmed for it without instructor intervention. The contingencies which "trigger" the insertion of each malfunction may be partially or totally unique. The AMI feature is organized into instructional exercises consisting of a limited number (e.g., up to 10) preselected malfunctions each.

Purpose and Intended Use:

The purpose of the AMI feature, in contrast to the nonautomatic Malfunction Simulation feature in which malfunctions are inserted manually by the instructor, is to cause selected malfunctions to be inserted automatically upon the first occurrence during a simulated flight of previously specified events. The reduced reliance upon an instructor to initiate emergency procedures training will permit a relatively skilled pilot to practice selected emergency procedures when a simulator instructor may not be available to administer such training. An additional purpose of the AMI feature is to provide a greater degree of standardization in the selection and insertion of malfunctions during training than would be possible if it were necessary to rely solely upon various instructors to select and insert them. The increased standardization will facilitate the assessment of pilot skill in responding to malfunctions and will permit an increased degree of control over the content of training, i.e., over the simulated malfunctions to which each pilot is exposed during instruction.

The AMI feature will be used during advanced or continuation training activities to aid previously trained pilots in the maintenance of their skills related to recognizing and coping with aircraft malfunctions. The feature may be used with a simulator instructor in attendance to provide instruction and criticisms as may be appropriate. Alternatively, the use of the feature permits a pilot to review his emergency skills in a "self-study" or review mode. In any event, the AMI feature will be used when the primary purpose of the training activity is to conduct emergency procedures training for pilots who are already familiar with the malfunctions involved, or to provide a standardized situation in which pilot responses to malfunctions can be

evaluated. It will not be used to introduce pilots to malfunctions or in conjunction with other training activities for relatively unskilled pilots.

Function Descriptions:

ENTER. The AMI feature may be accessed through controls located at the IOS at any time during the conduct of training. The AMI feature cannot be employed during the replay of previously recorded flight.

SELECT EXERCISE. The instructor may select any one of the previously prepared AMI exercises for use during an instructional activity. The simulator need not be in a freeze status when this selection is made.

SELECT IC. The instructor may employ the selected AMI exercise with any set of initial conditions that define the simulation. However, to increase the likelihood that all the contingent conditions specified in the selected exercise are met, he may select a set of initial conditions that has previously been designated as optimum for the intended training and that is compatible with the profile to be flown. If he elects to make such a selection, he must do so before beginning the malfunction training activity. Selection of a designated IC set will increase the standardization of the training to be conducted and will always be a requirement when performance measures are to be recorded.

CONDITIONS MET. When the contingent conditions associated with each malfunction contained in the selected exercise have been met, the instructor will be alerted, and the malfunction will be inserted into the simulation. The malfunctions contained in the selected exercise will be inserted one at a time in the sequence in which the contingent conditions for each are met. The minimum time between insertions of such malfunctions will be the time required to provide the alert.

ALERT. As an aid in anticipating the onset of an automatically inserted malfunction, the instructor normally will be alerted to the impending event for a period of not less than 10 seconds. The Alert will identify the malfunction that is about to be inserted.

OVERRIDE. During the period of the Alert, the instructor may observe that the pilot is engaged in an activity that would make insertion of the malfunction at that time an inappropriate event (e.g., he may be having unexpected difficulty with a previously inserted malfunction). Therefore, the instructor may elect to override, i.e., cancel, the impending malfunction. Overriding a malfunction will have no effect upon the insertion of other malfunctions contained in the selected AMI exercise. The previously cancelled malfunction will not be available for subsequent automatic insertion during that instructional activity. The cancelled malfunction may be inserted at any time manually, however. If pilot performance is being recorded when a malfunction is overriden or inserted manually, the instructor's intervention will be prominently indicated in the record.

INSERT. If the instructor does not override the impending malfunction, it will be inserted automatically at the end of the Alert. Once inserted, the malfunction will occur in the manner prescribed for it in the simulation program.

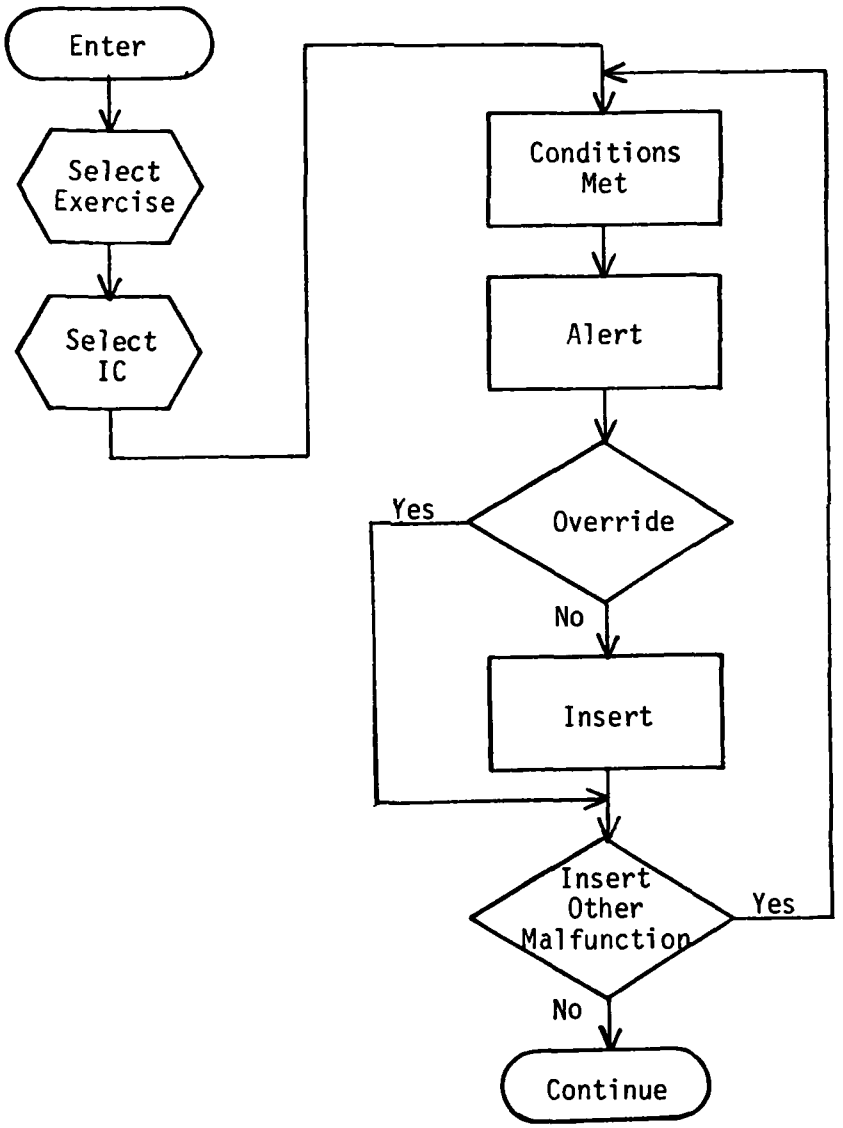
INSERT OTHER MALFUNCTIONS. Other malfunctions will be inserted automatically as described above as soon as the contingent conditions associated with each have been met. This process will continue automatically until all malfunctions in the exercise have been inserted or overriden unless interrupted by the instructor.

CONTINUE. The instructional activity will continue. The simulated aircraft will reflect the automatically inserted malfunctions until they are removed by the instructor or until the simulator is initialized for some other instructional or program development activity.

Concurrent Events:

The AMI feature may be used in conjunction with any ongoing instructional activity except those that involve replay of a previously recorded segment of simulated flight (e.g., Record/Playback and Demonstration). It will not be used with training activities that involve the automatic recording of pilot performance data for performance scoring or quality control of training purposes except when the selected AMI exercise is the training activity upon which the performance measures are desired. The feature may not be used during the development of automated training exercises and performance measurement scenarios. The Remove Malfunction functions associated with nonautomatically inserted malfunctions (Malfunction Simulation feature) may be employed to remove malfunctions inserted automatically when the AMI feature is used.

Feature Diagram:



Feature:

Automatic Malfunction Insertion Exercise Preparation

Definition:

Automatic Malfunction Insertion Exercise Preparation (AMI Prep) is a simulator instructional feature that enables a simulator instructor to prepare an AMI exercise for repeated use during subsequent periods of instruction. An AMI exercise consists of simulated aircraft malfunctions with single or multiple automatic insertion conditions specified for each.

Purpose and Intended Use:

The purpose of the AMI Prep feature is to permit AMI exercises to be prepared by selecting a set of malfunctions to be simulated during a subsequent instructional activity and identifying specific contingencies which, if met during such instruction, will "trigger" the insertion of each of the selected malfunctions without further instructor involvement. The skills required to prepare an AMI exercise using this feature are those normally found among simulator instructors who are pilots, and no additional technical training or computer programming skills are required. Nevertheless, it is expected that only designated instructors will prepare such exercises in order that exercise content may be controlled.

Preparation of an AMI exercise will be preceded by the development of a training mission profile or scenario to be used in conjunction with the particular malfunctions of interest. This scenario will provide a context within which the intended malfunction instructional activities can take place. It will also permit the instructor to determine when malfunctions should be inserted to be of most instructional value, and the insertion contingencies that are both probable as to occurrence and realistic as to the circumstances of occurrence. An AMI exercise will involve a maximum of approximately ten malfunctions.

In conjunction with the development of the scenario, the instructor will identify an initial conditions set to be used with the scenario. This is important because using a specified initial conditions set with a particular AMI exercise provides an additional degree of standardization for the planned malfunction instruction. If used with another set, the occurrence of a particular malfunction would be less predictable, and standardization of training would suffer. Where standardization may not be a concern, however, such as during practice sessions when an instructor may not be present, other initial conditions sets could be used with the AMI exercise.

Following development of a scenario which identifies the malfunctions to be included in the exercise and specifies the

contingencies to be used to trigger insertion of each malfunction, the exercise itself must be prepared. This is done interactively with the simulator through controls and displays located at the IOS. Using a programmed question and answer format, the instructor will identify one of the available simulated malfunctions and will specify the insertion contingencies to be associated with it. The contingencies will be specified in terms of arithmetic operations (equal to, greater than, less than) and logical operators (AND and OR) on parameters such as flight variables, time, position, preceding malfunction insertions, lethality algorithms, and events such as weapons release and gear extension. In specifying these contingencies, the instructor will select one or more parameters from among a set of programmed parameters, specify the logical operator involved (if more than one contingency parameter is selected), and "assemble" the contingencies desired to trigger each malfunction. Up to five different parameters can be involved in triggering each malfunction, although one or two will be sufficient in most instances. These exercise assembly activities will be repeated for each malfunction to be included in the exercise.

When completed, the AMI exercise may be reviewed by inspecting a display at the IOS. The display will identify the initial conditions set or sets that are appropriate for use with the exercise, the malfunctions included in the exercise, and the triggering parameters and designated operators associated with each. The flight profile appropriate to the exercise also will be indicated.

After assembling an AMI exercise in the manner described, it will be stored with other exercises and made addressable for subsequent use during simulator instructional activities. The display of the assembled exercise will be available for subsequent use by instructors as an aid when the exercise is being used.

Function Descriptions:

ENABLE. Preparation of an AMI exercise is a function that cannot be performed while instruction is in progress. To assure preservation of previously prepared exercises and to maintain administrative control over preparation of new ones, the AMI Exercise Prep feature must be intentionally enabled.

IDENTIFY INITIAL CONDITIONS SET. When standardization of malfunction training is desired, the set of initial conditions to be used with the AMI exercise must be identified as an aid to subsequent users of the AMI exercise in preparation.

SELECT MALFUNCTION. The malfunctions identified for inclusion in the exercise must be selected, singularly, from among those available in the simulation. The order in which they are selected is unimportant and may be unrelated to their order of insertion.

SELECT PARAMETER. After each malfunction has been selected, the desired triggering parameters to be associated with it must be selected before the next malfunction can be selected. The parameters are selected, singularly if more than one is to be associated with a

particular malfunction, from among those stored in the simulation program for that purpose.

DESIGNATE VALUE. When a parameter is selected that can have a specific value, the value must be designated for it. For example, if the selected parameter is time since exercise initiation, the number of minutes desired must be indicated; if the parameter is altitude or airspeed, the desired values must be indicated in feet (or meters) or mach number, respectively.

DESIGNATE OPERATOR. If it is desired that more than one parameter be associated with the triggering of the malfunction, a logical operator (AND or OR) must be designated along with the selection of each parameter after the first.

ALL PARAMETERS SELECTED. The functions described above for the specification of triggering contingencies for each selected malfunction may be repeated until each of the parameters prescribed in the previously prepared scenario has been selected and the appropriate values have been designated. The maximum number of parameters that can be associated with each malfunction is five.

ALL MALFUNCTIONS SELECTED. The functions described above may be repeated until each of the malfunctions designated in the prepared exercise scenario, together with the contingencies designated to trigger each, have been added. The maximum number of malfunctions that can be included in a single exercise is 10.

PERMANENT STORAGE. When the exercise has been prepared and reviewed by the instructor, and he is satisfied with it, it will be stored with other AMI exercises and will be available for use during subsequent periods of instruction. Designation of a storage location and effecting the storage is a program development function.

Concurrent Events:

While an AMI exercise is being prepared, the simulator will be in a freeze status. Concurrent training activities will not take place. However, all IOS controls and displays that normally function during periods of freeze will function in their normal manner during AMI Exercise Preparation. These include all controls and displays associated with manual data entry, deletion, and change; data display; and generation of hardcopy records.

Feature Diagram: